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Lamm-Wirth Task Force Membership

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Abbreviations Used

AEC	Atomic Energy Commission
ALO	Albuquerque Operations
ALOO	Albuquerque Operations Office
ATMX	Army Transport Model Special
BEIR	Biological Effects of Ionizing Radiation
CDH	Colorado Department of Health
CRS	Colorado Revised Statutes
DMA	Department of Military Affairs (Colorado)
EIS	Environmental Impact Statement
EPA	Environmental Protection Agency
ERDA	Energy Research and Development Administration
HEPA	High Efficiency Particulate Air
ICRP	International Commission on Radiological Protection
LASL	Los Alamos Scientific Laboratory
LEM	Lunar Excursion Module
MPBB	Maximum Permissible Body Burden
MPLB	Maximum Permissible Lung Burden
NCRP	National Council on Radiation Protection and Measurement
NRC	Nuclear Regulatory Commission
NRPB	National Radiation Protection Board (England)
QF	Quality Factor
Rad	Radiation Absorbed Dose

RF	Rocky Flats
RFP	Rocky Flats Plant
RMA	Rocky Mountain Arsenal
USAEC	United States Atomic Energy Commission
USGS	United States Geological Survey

Introduction

The Lamm-Wirth Task Force on Rocky Flats nuclear facility was appointed by Governor Richard Lamm and U.S. Representative Timothy Wirth in December, 1974 and was charged with developing options, alternatives, and recommendations to enable the Governor and Congressman to fully understand and deal with the RF (Rocky Flats) operation. The Task Force commenced its work shortly thereafter, studying the operation of the Rocky Flats Plant (RFP), the hazards associated with it, its impact on the environment, and the legal and occupational problems associated with the facility. The Preliminary Report, issued by the Task Force in February, 1975, was intended to serve as a basis for public hearings held in Denver and Broomfield on April 14 and 15, respectively. Transcripts of the public hearings (see Appendix A for list of participants) are available for public perusal at the Colorado Department of Health (CDH). This final Task Force report consists of two parts: (1) recommendations to Governor Lamm and Congressman Wirth and (2) a Documentary Report of the RF operation and the most important technological information associated with understanding the operation.

The Task Force reflected on many facts and impressions during its nine month existence. Some of these made profound impressions. Public testimony on April 14 and 15 made it clear not only that many people had only rudimentary knowlege of the operations at RF, but also that there were grave misgivings about the Plant's safety and the potential for a cataclysmic accident. Our Documentary Report is intended as an educational statement prepared to place the Rocky Flats Plant (RFP) into an objective and proper perspective. Although we believe that such a plant can under ideal conditions be operated safely, we have become

aware of a number of specific occurrences which cause deviations from the ideal. These are noted as follows:

(1) It is our impression that the most serious environmental off-site release from the RFP (see discussion of the lip area in Chapter III, Section A*) occurred with the full knowledge of the RFP. The release occurred over a long period (1958-1969); it was discovered by RF people in 1959, but no action was taken to stop the leakage until 1966.

(2) A recent action carried out with all good intentions by the RFP served to illustrate to the Task Force that potentially serious incidents can still occur. The Governor's office, the CDH, and the Energy Research and Development Administration (ERDA) Headquarters had determined that any action taken to alter the lip area would have to be agreed upon by these concerned parties. Despite this agreement Dow Chemical, some time in the early summer, sprayed defoliant on the lip area vegetation. This action could have seriously upset the stabilization of the plutonium that had been established in the soil if a soil retention blanket had not been added to the area. The Task Force has evaluated this action with the help of the RFP and the CDH; the defoliant did not work particularly well and the plutonium in the soil appears stable (Chapter III, Section A).

(3) Another serious accident, the release of tritium into the Broomfield water supply (Chapter III, Section A), occurred in 1973. Although we believe the RFP did not know that tritium was present in the material to be reprocessed, we find it deplorable that no procedures existed to insure that the RFP was properly apprised of the constitution of the material it received.

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* Parenthetical references are to chapters and sections in the Documentary Report.

(4) Finally, the recent accidents (July 30 and 31, 1975) in which two workers were contaminated in the plutonium recovery area (Chapter IV, Section H) point out again that potential hazards often convert to real ones. The Task Force has only limited information on these recent accidents since, as of this writing, neither they nor the CDH were given official notification of the occurrences.

We believe it an inescapable conclusion that there is risk associated with the RFP. Since the Task Force is unable to authoritatively assess many of these risks, we have asked in our recommendations that independent agencies investigate into many of the areas where we felt lacking.

It seems certain that if the criteria (Chapter II, Section A) evaluated for the original siting of the RFP were applied for siting today, the RFP would not be located near a densely populated area. We recognize that it is beyond our charge to evaluate the benefits associated with the continued operation of facilities like the RFP and expect that such evaluations are ongoing in the upper echelons of the U.S. Government. The certainty that such a plant would not today be located at Rocky Flats, as well as our feeling that accidents will continue to occur even under the best circumstances, dictate our belief that such a plant should not be located at Rocky Flats. Recognizing the potential hazards associated with the location of the plant, the Task Force believes any burden of proof rests with ERDA and Rockwell to guarantee the health and safety of the workers as well as the population surrounding the RFP.

We have addressed ourselves to constructive recommendations regarding both the optimal operation and final fate of the RFP. We believe that as the present mission is phased out, a less hazardous one should be assigned to the RFP while the economic integrity of the Plant, its employees, and surrounding

communities are carefully preserved.

We believe that the health and safety of all workers at the RFP and citizens of Colorado is paramount. We have assumed, when technological knowledge was insufficient for us to make a good judgment, that we should err on the conservative side. The Task Force fully realizes that this approach may not be met with total acceptance by ERDA and Rockwell International, but feel safe that this philosophy will best protect those who might be directly affected.

RECOMMENDATIONS

Recommendations

1. A permanent Monitoring Committee should be established to continue the work of this Task Force. Its makeup should include a balanced representation of the public. This Committee should be provided with paid staff with appointments being made by the Governor and the District Congressman. Ultimate responsibility for funding the Committee should rest with the Federal government.

The Committee's duties should include but not be limited to:

(1) Regularly reporting to the Governor, the District Congressman, and the public.

(2) Developing procedures to assure that the Committee, the Governor, the District Congressman, and the public will be given adequate advance notice of any proposal to substantively change the mission, level or nature of activities at the Plant. Furthermore these procedures should assure that no such changes be implemented without publication of adequate environmental impact statements, study and publication of recommendations by the Monitoring Committee, public hearings, and Congressional and State approval.

(3) Advising the Governor of the State of such proposed changes and their effect, and also of the Committee's recommendation for action by the State of Colorado.

(4) Evaluating all aspects of plant management with respect to health, safety, and the environment. In carrying out this responsibility

that the Federal government, in cooperation with the City of Broomfield and all appropriate County and State officials, provide the City of Broomfield with an alternate source of water to replace the water which Broomfield receives from the Great Western Reservoir. (Chapter III, Section A (a)).*

3. The Task Force recommends that Governor Lamm and Congressman Wirth request:

   A. Congress and the President of the United States should reassess the Rocky Flats Plant as a nuclear weapons component parts manufacturing facility. In reassessing the Plant as a weapons manufacturing facility, consideration should be given to a program of gradually phasing out its present operation, possibly transferring those operations to a more suitable site, and decontaminating and converting the Plant's facilities to a less hazardous energy-related industry, such as solar energy research and development. In evaluating these alternatives, strong consideration should be given to maintaining the economic integrity of the Plant, its employees, and the surrounding communities. (Chapter II, Section A).

   B. Congress and the President of the United States conduct a thorough investigation of the Rocky Flats Plant to determine whether security at the Rocky Flats Plant is adequate to prevent (i) sabotage and terrorism of the Plant and (ii) surreptitious removal of radioactive material. (Chapter IV, Section C).

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* Parenthetical references in the recommendations are to chapters and sections in the Documentary Report.

C. The Federal government advise the State of Colorado on a regular basis of its short and long-range planning in all nuclear programs which will have impact on both the nature of the mission and the level of production at the Rocky Flats Plant.

4. The Task Force recommends that Governor Lamm and Congressman Wirth seek to obtain the gradual introduction at the Rocky Flats Plant of research and development operations related to less hazardous uses of energy. We believe that operations such as those currently carried out at RFP should be located in areas remote from any population center.

5. Regarding Medical Studies and Occupational Health we recommend that:

A. Governor Lamm and Congressman Wirth recommend to the Federal government that it fund a comprehensive and independent epidemiological study of short and long-range effects of exposure to various levels of both external and internal radiation from transuranics elements in all past, present, and future transuranic workers. The study should be directed by experts of the highest qualifications. Funds should be committed for a minimum period of twenty years so that the study can not be terminated before enough reliable data have been collected and analyzed.

All epidemiological studies presently in progress or being planned should be coordinated to assure maximum value of results of any of these studies. Similar studies should be carried out

on an appropriate animal model.

Similar studies should include all past, present, and future RFP plutonium workers, but certainly not be limited to them. A nationwide study including all plutonium workers is necessary to most efficiently study these problems. (Chapter V, especially Sections C and D), (Chapter VI, Section I).

B. An organized and concerted effort should be made to register all past, present, and future Rocky Flats employees with the Transuranium Registry authorizing release to the Registry of these individuals' exposure and medical records during their lifetime and of autopsy data after their death. This effort should be coordinated between ERDA, past, present, and future contractors, and labor organizations at the Plant. (Chapter VI, Section I).

C. Since the stated primary purpose of the Transuranium Registry is ". . . . to protect the interests of workers, employees, and the public by serving as a National focal point for the acquisition and provision of the latest and most precise information about the effects of the transuranic elements on man," we recommend that the Advisory Committee and the management of the Transuranium Registry should be made up primarily of persons representing transuranium workers, employees in nuclear facilities, and the general public. (Chapter VI, Section I).

D. To alleviate the severe problem of maintaining contact with all transuranic workers throughout their lives, all such workers should be given free lifetime health care similar to that provided to the military.

E. A Federal nuclear workers health and compensation act should be enacted which could provide any plutonium worker or any other worker in a nuclear industry who is exposed to radioactivity and who contracts cancer, whether occurring during his period of employment or after he has left the employment or retired, with medical treatment and financial compensation if he is unable to work without the necessity of proving causation between the radiation exposure and cancer. (Chapter VI).

F. The results of the above studies (Recommendation 5A.) should be used to revise the present State occupational disease acts with respect to illnesses in workers which may be caused by exposure to transuranic elements. (Chapter VI, Section E).

6. Regarding Public Information the Task Force recommends:

A. An agreement should be obtained from ERDA and its contractor that they will provide speedy, accurate, and detailed information concerning all radiation accidents which occur at the Plant such as the two which occurred during the last week of July, 1975. This information should be disclosed to the Governor, the Congressman, the CDH, the Monitoring Committee, and the media. This agreement should provide for regular followup disclosures at specific intervals

concerning decontamination of any plant facilities, reduction of radiation levels, and health condition of any individuals affected. (Chapter IV, Section H(a)).

B. All information concerning radiation goals established in the Plant and progress reports on achieving those goals should be regularly made available to the public in an understandable form. Efforts should be made to encourage the local media to publish this information on a regular basis.

C. State universities, public schools, and State and local health departments should be charged with the responsibility and provided with the funds (by Rockwell, ERDA, HEW, and/or other Federal sources) to educate the workers at Rocky Flats and the public about the short and long-term effects of plutonium, americium, and other radionuclides on humans and other living things. These programs should present both the point of view of the environmentally concerned community and of the nuclear industry and the military.

7. Regarding Monitoring of Employees the Task Force recommends that:

A. Outside independent experts annually review all monitoring equipment and procedures to ensure that the best available equipment and measures are being appropriately used. (Chapter IV, Section G).

B. Accurate records of each employee's individual radiation exposures be compiled by ERDA's contractors and permanently preserved in cooperation with the Colorado Department of Health (CDH). (Chapter IV, Section G , Chapter VI, Section A).

C. That procedures be developed to provide access to this information, in a matter consistent with privacy of the individual involved, to the Colorado Department of Health and other appropriate agencies on a regular and frequent basis. (Chapter VI, Section A).

D. That a program of radiation exposure goals should be developed and given top priority by the Rockwell management. It should include publication of exposure levels in individuals by group and work areas throughout the Plant as well as exposure levels of that area of the Plant itself. It should be combined with a system of rewards and incentives for those who achieve and maintain the goals established. The goals should be determined and periodically reviewed by management, employees, the CDH, and the independent Monitoring Committee. (See Recommendation Number 1).

E. Such information be required to be provided to each employee no less frequently than once per month in a readily understandable form with comparison of past levels of exposure and exposures of others in his work area and the Plant in general.

F. High priority and allocation of resources should be devoted to developing and improving radiation protection systems for humans both in and outside of the Plant.

G. A program should be developed to re-evaluate present and former Rocky Flats employees with new, more sophisticated detection systems. The program should be designed to achieve maximum participation by these employees consistent with their right to

privacy and psychological resistance to this type of information in the past. (Chapter VI, Section I).

H. Federal impact funds should be provided to the State of Colorado to insure that programs are funded to provide the most up-to-date equipment and competently trained staff to regularly monitor the operation of the Plant and its impact on the environment.

I. ERDA should provide funds to the State to acquire, operate, and maintain the most sophisticated monitoring instruments for determining plutonium lung burdens. This is necessary to assure the workers and citizens that the best available methods are currently being used at Rocky Flats and that workers are accurately informed of the extent of their plutonium lung burden. (Chapter IV, Section G).

J. The Federal government should appropriate substantial research and development funds for continuing development of ultra-sophisticated bioassay techniques and monitoring equipment. (Chapter IV, Section G).

8. Regarding Safety the Task Force recommends:

A. The Nuclear Regulatory Commission, Occupational Safety and Health Administration, and/or all other appropriate agencies, independent of the Operational Safety Division of ERDA, should be requested by Governor Lamm and Congressman Wirth to conduct routine comprehensive studies of all safety aspects at the Plant and should make proposals for improved safety in plant operations to prevent radiation and/or other accidents. Timely results of such inspection should be made public. (Chapter IV).

B. The Federal Aviation Administration should restrict the air space over and near the Plant by appropriate regulation and stringently enforce this regulation in cooperation with local law enforcement authorities and the administrator of the Jefferson County and other local and regional airports. We recommend that no expansion of the Jefferson County Airport occur until our recommendation of change of mission has been fully implemented. If the mission is not changed we believe airport expansion is incompatible with the close proximity of the airport to the RFP. (Chapter IV, Section H (a)).

C. Transportation of all nuclear material both on and offsite of the Rocky Flats Plant and other nuclear facilities in Colorado should be monitored by the CDH. Regular reports consistent with National security should be made to the Monitoring Committee. (Chapter IV, Section H (c)).

D. All appropriate Federal and State regulatory agencies should cooperate in developing guidelines for controlling air transportation of plutonium and other transuranic elements.

9. Regarding Land Use the Task Force recommends:

A. The Federal government should acquire land for an additional buffer zone around the Plant. This buffer zone (we suggest an additional one-to-two miles on each side) should provide additional protection from a possible nuclear disaster at the Plant and should include, but not be limited to, all land contaminated to or above the existing State soil guidelines. (Chapter IV, Section A and F), and(Chapter VI, Section G).

B. The Board of County Commissioners and local governing bodies in Boulder and Jefferson Counties should be requested to declare a moratorium, if possible, on further development of any land in the vicinity of the Plant which exceeds the Board of Health's recommended soil standard as well as any land within the proposed additional buffer zone. This moratorium should remain in effect until the Federal government has an opportunity to acquire these lands or provide funds to State and local governments for their acquisition. (Chapter VI, Section G).

C. Colorado Land Use Statutes should be amended to give the State and local governments clear authority to restrict development on contaminated lands and land in the vicinity of hazardous facilities. (Chapter VI, Section G).

10. Regarding Emergency Response Plans the Task Force recommends:

A. That appropriate emergency response plans be prepared and implemented to provide responses to a wide variety of potential accidents at the Rocky Flats Plant. Such responses might affect small or large numbers of people both on- and offsite. These plans should consider evacuation and alternatives thereto. Frequent plan reviews, updates, and checks to assure their efficacy and the high state of readiness of involved personnel must be carried out. Frequent mock emergency drills of both on- and offsite responses should be conducted under supervision of the Department of Military Affairs, the Colorado Department of Health, and the Monitoring Committee. (Chapter IV, Section D).

B. Plans should be developed and implemented under agreements with area hospitals to provide emergency treatment to small or large numbers of contaminated individuals who might require intensive care. Procedures should be instituted for updating such agreements and for insuring that appropriate personnel at these hospitals are familiar with and skilled in implementation. Plans should be reviewed regularly by the Colorado Department of Health. (Chapter IV, Section D).

C. An independent study should be conducted to determine the adequacy of the entire on- and offsite emergency response plans.

D. An independent study should be done of the maximum credible accidents which might occur at the plant to include any incidents of bombing, other acts of sabotage, or a major airplane crash into a plutonium facility. This information should also be included in the upcoming Environmental Impact Statement. (Chapter IV, Section H (a)).

11. Regarding the Environment the Task Force recommends:

A. Federal law should be clarified to unequivocally grant authority to the Environmental Protection Agency (EPA) to control and regulate all discharges of radioactivity by contractors of Federally operated nuclear facilities. EPA should establish standards for plutonium and americium in soil under various conditions of climate, wind, vegetation, soil chemistry, land use, degree of access to the

public, and proximity to residential areas. The Rocky Flats buffer zone and surrounding areas should be resurveyed at yearly intervals to monitor the spread of these elements. (Chapter IV, Section A).

B. A policy of striving toward zero discharge of any radioactive or highly toxic substance at the Rocky Flats Plant should be adopted and all necessary resources should be committed to achieving that goal. (Chapter IV, Section H (b)).

C. An independent study to assess the adequacy of all plutonium buildings (as well as the plutonium recycling and waste processing building presently under construction) to withstand all natural and human caused credible disasters should be performed. (Chapter IV, Section H (a)).

D. ERDA and Rockwell should carry out a complete particle size analysis of all stack effluents containing hazardous materials. (Chapter IV, Section H (b)).

E. High priority should be given to support the release prevention and detection systems with adequate manpower to maintain the existing systems and to change all filters according to a fail-safe schedule which is closely monitored by the CDH and the Monitoring Committee. (Chapter IV, Section H (b)).

F. Experts on aerodynamic sampling techniques should be commissioned to study the present system of ambient air sampling. This study

should be conducted by an independent, highly qualified group mutually agreed upon by ERDA and the CDH.

12. Regarding Formal Impact Statements the Task Force recommends:

A. Before the Rockwell contract is renewed or bids are opened for other contractors to replace Rockwell, a current Environmental Impact Statement should be prepared. In addition, ERDA should not only conduct public hearings on the performance of Rockwell, but also seek input from the Monitoring Committee, the CDH, the Governor, the Congressman, and any and all interested citizens and groups. Periodic evaluations of the contractor by ERDA management on performance should be made public at regular intervals and provided to the Monitoring Committee, the CDH, the Governor, the Congressman, the public, and the media.

B. A separate EIS should be required immediately for the removal of all nuclear and non-nuclear toxic materials buried or otherwise contaminating the soil at or near the Plant site. (Chapter IV, Section H (c) and Chapter VI, Section J).

13. Regarding Legislation the Task Force recommends:

A. Congress should enact legislation subsidizing the State of Colorado and the county or local governments for impact costs incurred by any State governmental units because of the existence of Rocky Flats, including but not limited to: (a) health, safety, and environmental monitoring; (b) training of hospital and other emergency personnel; (c) maintenance of hospital and other emergency equipment;

(d) establishment of the Monitoring Committee and proper staffing thereof; (e) environmental decontamination; and (f) cooperative public education program.

B. The Price-Anderson Act should be repealed and replaced with a nuclear industry liability act which requires contractors and licensees to bear the risk of doing business in the industry and to obtain and maintain their eligibility for adequate insurance without limits of liability. Strict liability on the part of the contractor or licensees should be provided for by Federal law in the event of accidents which cause any injury or damage to persons or property not employed by or owned by the government or the contractor/licenses. A reasonable statute of limitations, not unrealistically short, should be provided. Waivers of all defenses including sovereign immunity must be the condition of all contracts and licensees in this field. All distinctions under existing legislation should be eliminated between different kinds of incidents and administrative discretion by Government agencies should be prohibited in determining the nature of an incident and scope of liability. (Chapter VI, Section C).

C. The Nuclear Facilities Act, passed by the Colorado House of Representatives during the 1975 Legislature but killed in the Colorado Senate, should be enacted into law. It should be put on the Governor's call for next year's legislative session and should be given high priority by the Governor's staff to assure its enactment. (Chapter VI, Section K).

14. Regarding Medical Facilities Related to Rocky Flats the Task Force recommends:

A. The head of the medical staff should be a physician with expertise both in the area of emergency service and in the special problems associated with injuries due to radioactive substances, particularly with regard to emergency surgery and decontamination procedures.* This should include knowledge of monitoring techniques and appropriate instrumentation. Such expertise should be documented by evidence of formal training in these areas. There should be a similarly trained alternate to the head of the medical staff. (Chapter IV, Section D).

B. The nursing staff should receive training in the special problems nurses may face in handling patients at the RFP. (Chapter IV, Section D).

C. The medical facility should include equipment necessary for minor surgery and for some major surgery (e.g., orthopedic or plastic) that could be accomplished more conveniently at Rocky Flats (perhaps by an outside consultant). This would require obtaining equipment for general anesthesia. (Chapter IV, Section D).

D. All medical personnel at Rocky Flats including physicians, nurses, health physics personnel and any others involved in preventing and

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* The person now in charge is presently undergoing this type of training.

treating radiation hazards should be required to receive a specified number of hours of continuing education courses each year. Programs should be developed and coordinated between ERDA, ERDA contractors, and the CDH. Regular drills for treating various radiation health emergencies not requiring offsite treatment should be conducted under the review of the CDH. (Chapter IV, Section D).

15. Regarding Contract Provisions the Task Force recommends the following modifications to the Rockwell contract:

A. Provide for frequent unannounced inspections without notice to the contractor by both ERDA and the appropriate agencies referred to in Recommendation #8A. The results of these inspections should be made available to the public, the Monitoring Committee, the district Congressman, and the Governor.

B. Require the contractor to exercise the "utmost skill" to assure safe operating conditions for employees as well as the public particularly in view of the hazardous nature and potential danger from the existence and operation of this Plant.

C. Expressly add to the Rockwell contract as a separate provision that Rockwell preserve individual occupational radiation exposure records. Such a provision was present in the Dow Chemical contract.

16. In the past the AEC, now ERDA, has had the responsibility and the mandate to monitor and regulate the contractor at the Rocky Flats Plant in the public interest particularly with respect to public and employee health and safety.

Notwithstanding this responsibility, it appears to us that the AEC in the past operated under a policy of withholding and distorting information from the public with respect to the Plant's operations. We, therefore, recommend that Governor Lamm and Congressman Wirth request that Congress authorize the Government Accounting Office to conduct an investigation into the facts surrounding this apparent past policy and to impose any appropriate sanctions it determines are necessary to assure that such a policy will not be instituted again.

DOCUMENTARY REPORT

Author's Preface to Documentary Report

The author was engaged on May 29, 1975, by Governor Lamm's office, to serve both as a technical staff member to the Lamm-Wirth Task Force on Rocky Flats and as the author of the Task Force's Documentary Report. The Documentary Report has been prepared as an introduction to the Rocky Flats Plant. Every attempt has been made to keep it simple and nontechnical. It is, of course, impossible when dealing with a technical subject to be entirely successful in these objectives. Yet it is hoped that the attempt will make available to citizens of Colorado a readable account of the operations at Rocky Flats and their health and safety impact on both the workers of the Rocky Flats Plant and the citizens of Colorado.

Many individuals have helped in bringing the final report to completion. Some of those who have supplied technical information and to whom thanks are given are Professors Wesley Lemasurier and Clyde Zaidins, University of Colorado at Denver, Dr. Stuart Smith, University of Colorado Medical School; Bert Crist and Jim Montgomery of the Colorado Department of Health, and Robert Rich, Attorney at Law. In addition, the Task Force, many individuals at the Rocky Flats Plant, Barbara Radosevich of Governor Lamm's office, and the secretarial staff, in particular Mrs. Margaret Little, at the Colorado Department of Health, have been extremely helpful. Finally, Robert D. Siek, Chairman of the Task Force and Assistant Director of the Colorado Department of Health, and Albert J. Hazle, Director of the Occupational and Radiological Health Division of the Colorado Department of Health, have been instrumental in assisting the

author's education as the report was being written. Their patience and friendship have made the process both rewarding and exciting.

August 15, 1975

Dr. Robert Damrauer
Department of Chemistry
University of Colorado at Denver

CHAPTER I

Introduction:

The Task Force Documentary Report was prepared as a summary of the factual material gathered from not only the public hearing participants and individuals who have corresponded with the Task Force, but also from our investigations of the literature relevant to the RFP. Most of the reference material used in preparing the final report is available at the CDH (Colorado Department of Health).

Because of the scope of the Task Force's undertaking, the Documentary Report will not discuss in detail information communicated in the Preliminary Report. Rather an attempt has been made to present an organized account of the Rocky Flats operation and its effect on the citizens of Colorado.

Aids to the Reader:

The reader should be aware of several limitations that may have influenced this final document. The most important is that the Task Force itself has taken on an enormous task and tried to come to its conclusions in a relatively short time span. Its members are not experts in all areas covered in this report and, although expert outside help has been sought, some areas are better treated than others. Further, many areas of concern to the Task Force have not been adequately studied either because such studies are as yet incomplete or because the issues involved have only recently been considered important enough to initiate studies.

The Task Force has also had to face the problem of dealing with considerable amounts of data from studies generated within the United States Energy Research and Development Administration (ERDA) system. Such data, although not necessarily questionable, is often generated and dispersed in a manner uncommon for scientific publications. That is, oftentimes studies are carried out within the system and publications are dispersed without the benefit of review by anonymous peers. This tendency is in some cases necessary because of the sensitive nature of the information gathered. It should also be pointed out that the new agency, ERDA, seems more open and willing than its predecessor to subject its scientific work to outside scrutiny.

Finally, we would emphasize that in this report there is a good deal of discussion about radiation standards. Many scientists and laymen are concerned that these standards are unsafe--that is, too high. It is important to understand that standards are established on the basis of currently accepted hazards. These are established as one might expect by experience. Although the dangers may in the future prove to be graver than can now be identified, those recommending standards deal only with current knowledge. Although the Task Force cannot set different standards it can point out that radiation standards have almost always been lowered as more information about radiation hazards have been accumulated. Perhaps it is obvious to suggest that if we are to commit errors in establishing future radiation standards that they may be on the conservative, safe side always aware that such standards are established by risk-benefit analysis seeking levels that are both safe and economical.

CHAPTER II

History and Brief Description of the Rocky Flats Plant

Introduction:

In this chapter we briefly review the history of the RFP including the selection of the RF site, an outline of the operations of the plant, and a description of the present site.

A. Site Selection:

Construction of the Rocky Flats Plant, located about seven miles west of Broomfield, was begun in 1951. Selection of the site was based on an engineering study by the Austin Company[1] designed to satisfy criteria established by the Santa Fe Operations Office* of the Atomic Energy Commission (AEC), and the Dow Chemical Company. Generally, the criteria involved (1) general Western location, (2) minimal site and plant sizes, (3) reasonable distance from a population center of 25,000 or more, (4) minimal displacement of homes and population for site construction, (5) dry, moderate climate, (6) proximity to main railroad line, (7) proximity to good main highway, (8) proximity to major airport, (9) dependable primary and alternate power sources, (10) adequate water supply, (11) adequate gas, oil, or coal fuel supply, (12) normal sewerage facilities, (13) drainage above possible flood levels, and (14) attractiveness of area to skilled personnel

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* Later was relocated and became the Albuquerque Operations Office (ALOO)

moving to the region. The most important criteria were later determined to be (1) a dry, moderate climate, (2) adequate supporting population, (3) attractive environs, and (4) ready accessibility to Los Alamos, Chicago, and St. Louis. Examination of the criteria established only three suitable locations: Denver, Pueblo, and Colorado Springs, Colorado. These were each of suitable size and had dry, moderate climates. Pueblo was dismissed as being less attractive to workers, less accessible, and as having another vital industrial operation; Colorado Springs was considered to be only minimally suitable with respect to power resources. Having selected Denver as the best locality, seven alternate plant sites were examined. Again, the criteria were applied and finally Rocky Flats and a site adjacent to the Rocky Mountain Arsenal (RMA) were chosen. The main disadvantages of the RMA site were (1) dependency on both water and power lines already serving RMA, (2) likeliness of dusty site conditions resulting from sandy soil, and (3) undesirable public reaction to another secret project "close to the civilian installations northeast of Denver and in the South Platte Valley." Final recommendation of Rocky Flats was based on:

"a) Its terrain provides a desirable combination of a mesa and ravines.

b) Its deep beds of gravel provide good foundation conditions.

c) The gravel surface, its altitude above the sandy farm land to the east, and the closeness of the foothills of the Rocky Mountains provide maximum protection from wide-spread or local dust storms which would disrupt the important ventilation system.

d) Water from a reservoir of the City of Denver is reasonably accessible.

e) It enjoys maximum reliability of electrical power from adjacent

transmission lines with multiple generating sources.

f) It is within reasonable driving distance and time of Denver, Boulder, and Golden, over good highways with very little commuting traffic.

g) It is about two miles from the Denver, Rio Grande and Western Railroad's Moffat Tunnel mainline. It would be feasible to extend a sidetrack to the site if this should be desirable.

h) The property is the least valuable of the seven Denver sites considered and should be obtainable for the least cost.

i) The site has the least occupancy of the seven Denver sites; only one homestead was apparent.

j) It is remote from any industrial installation or conceivable military target.

k) It is easily adaptable to any desired degree of plant security control.

l) It is ideal from the viewpoint of public relations: minimum displacement of homes, land used only for minor grazing, and well removed from any residential area."[1]

The engineering report[1] cites only one disadvantage for Rocky Flats; namely, that it is far.(27 miles) from Stapleton Airport.

Of the information reported in the Austin engineering report[1], the data on wind directions proves the most interesting. The report states that the site be located on the leeward side of any dense population and further indicates that the prevailing winds in the Denver area are from the south. This proves to be erroneous since winds at Rocky Flats are predominately from the west[2]. Stapleton International Airport's wind stations, on the other

hand, record most frequent winds from the south and southwest.[2] In general, then, air passing over Rocky Flats merges with air that has passed over Denver and is dispersed to the northeast. The Task Force strongly would emphasize not only that Denver's population has exploded since the RFP was located and that certain siting criteria were poorly applied, but also that no public input went into the original siting. (See Recommendation 3A).

B. RFP Operation:

The Rocky Flats Plant began its operations in 1953 as part of the nuclear weapons complex administered by the Albuquerque Operations Office (ALOO) of the AEC.[3] Santa Fe Operations were designated as the primary development and production organization for nuclear weapons in 1943. Its assignment has not notably changed through the years, being largely concerned with "research, development, production, testing, stockpile surveillance, and transportation" of nuclear materials.[3]

Albuquerque Operations can be divided into three areas:[3] (1) research and development laboratories, (2) production, and (3) other operations. Research and development are largely carried out at the Los Alamos and Sandia Laboratories. The Los Alamos Scientific Laboratory's (LASL) "primary mission is research and development of explosive systems of nuclear weapons." In addition, basic and special research have become increasingly important to LASL to the point where about 50% of the Laboratory's efforts are now devoted to nonweapons programs. These projects include thermonuclear reactions for power, plutonium fuels development, studies of the effects of nuclear radiation on molecular and cellular levels, biophysical and biomedical research, as well as others. The Sandia Laboratories are located in Albuquerque, New Mexico and Livermore, California. In Albuquerque, Sandia's mission has been largely

connected with ordnance engineering, nuclear bomb assembly, and military training although a more basic nonweapons research program is now carried out. The Sandia Livermore Laboratory is responsible for ordnance systems engineering for weapons conceived at the Lawrence Livermore Laboratory.

There are Albuquerque Operations (ALO) production facilities in Amarillo, Texas; Kansas City, Missouri; and Pinellas, Florida. Table 1 lists some of the work carried out at these facilities.

Other ALO administered operations include biomedical research and university-ERDA laboratory cooperative projects.[3]

From Table 1 we see that Rocky Flats is the primary plutonium fabrication facility for ALO. The Plant's operations were contracted to Dow Chemical until recently when, on July 1, 1975, Rockwell International, Atomics International Division, became the prime contractor. Appendix B of the contract between ERDA and Atomics International defines the scope of work as: "(1) manufacturing design and development, fabrication, and assembly of nuclear weapons components and subassemblies, (2) reimbursable work as requested or approved by the Commission, (3) reimbursable work, including development support and fabrication and assembly of special components, as delineated in work orders issued by Design Agencies or other Commission (ERDA) contractors, provided that the undertaking of such work on any particular work order requires prior Commission approval if (a) it is not consistent with the Rocky Flats Plant's mission assignments, or (b) requires the expenditure of funds for capital plant and/or equipment in excess of $50,000, (4) development work on both product and process as required to carry out the production mission, including related manufacturing research carried out as a part of the continuing long-range effort to improve production performance, (5) other work related to the mission of the Rocky Flats Plant,

TABLE 1

ALO PRODUCTION FACILITIES AND THEIR ASSIGNMENTS[3]

Facility	Assignments
Amarillo-Pantex Plant	fabrication of chemical explosives development work in support of design laboratories nuclear weapons assembly nuclear weapons disassembly nuclear weapons component testing nuclear weapons repair
Kansas City-Bendix Corporation	procurement of complex electrical, electromechanical, and mechanical weapons components
Miamisburg-Mound Laboratory	manufacture of detonators and other explosive components for weapons process and distribution of gaseous isotopes (e.g., helium-3) production of plutonium-238
Rocky Flats-Rockwell Atomics International	"production facility, handling nuclear materials, where fabrication, manufacturing design and development, production engineering, and related activities are performed."[3]
Pinellas-General Electric	development and production of neutron gathering devices electronic and high vacuum technology

including recovery of certain radionuclides associated with test activities; extraction and purification of radioactive isotopes for Commission laboratory or private industrial use; and reclamation of specified weapons materials in support of the nuclear weapons retirement program."[4]

The principle materials handled at the RFP are elemental plutonium and its compounds. Other materials handled (both in the elemental and compound states) are americium, beryllium, and uranium as well as large quantities of chemicals like nitric acid and carbon tetrachloride. Elemental plutonium is man-made, produced by the neutron bombardment of uranium-238.* The chemistry of plutonium has been well studied. Its behavior is complex due not only to its chemical properties, but also because of its high radioactivity.[5] ** The biological effects of plutonium intake are less well studied[5] although such effects as are known will be detailed in later sections.

Plutonium and its compounds exhibit a high radiotoxicity;*** some materials are quite pyrophoric (ignite spontaneously). As a result plutonium materials must be assiduously excluded from environmental release and handled with extreme caution. The most abundant isotope in weapons grade plutonium is plutonium-239 characterized by a half life of about 24,000 years. This means that one-half of the plutonium-239 will still be present in 24,000 years. The rest will have spontaneously decayed mostly to other radioactive materials.

Americium-241 is a radioactive decay product of plutonium-241 and is recovered at the RFP and shipped to an isotope storage and distribution center

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* Elements followed by a dash and a number indicate which isotope of that element we are considering. The same element may have more than one mass (weight)-- these different masses are called isotopes.

** Radioactivity is the property of many chemical elements of spontaneously releasing radiant energy.

*** Radiotoxicity is the toxic property associated with the release of radiant energy.

in Oak Ridge, Tennessee. Although it is present in low concentrations in RF plutonium, it is considered[6] to be a great potential hazard. We have not detailed its properties or its potential hazards in an effort to keep the report simple. In no way would we minimize the potential hazards associated with americium; we urge that every effort be made to expand our knowledge in these areas.

Plutonium, being man-made, was unknown in the environment before its invention in the early 1940's. Since then it has been produced in large quantities and released by a number of occurrences. The major incidents are indicated in Table 2.

In addition to the quantities of plutonium already released to the environment, it is to be anticipated that additional sources will surface. A number of consumer products are being or have been developed containing either plutonium or closely related materials. These include americium smoke detectors, plutonium-238 well-logging sources, plutonium-238 mineral analyzers, and plutonium-239 heart pacemakers. Finally, the burgeoning nuclear fuel industry estimates the production of at least a million pounds of plutonium by the year 2000.* The estimated annual plutonium discharges from nuclear fuel reprocessing plants in 2000 are less than 0.2 curie per year; this, of course, assumes that there are no accidental releases.[7]

Table 2 indicates that the RFP's contribution to world-wide plutonium levels is slight (3-5 curie release). We will discuss in a later section what effects such releases may have on the local environment. Table 3 outlines some of the events at RF leading to the 3-5 curie offsite release.

Details of the dispersal of the radioactivity from the RFP to the local environs have been given in our Preliminary Task Force Report.[11] To briefly

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* Present uncertainties in the nuclear industry made this a very crude estimate.

TABLE 2

PLUTONIUM LEVELS FROM VARIOUS SOURCES[7,8,9]

Source	Distribution	Amount (curies)*
Fallout from weapons testing	World-wide	300,000-500,000**
Airborne from weapons testing	World-wide	Approx. 4,000
Fallout from weapons testing	Over United States	Approx. 10,000-15,000
Satellite burnup of Radioisotope Thermoelectric Generator (RTG)**	World-wide	17,000**
Reentry of Apollo 13 LEM (RTG)**	Believed to be intact in ocean	45,000
Fallout from testing	Nevada Test Site	1000 at least
Fallout from testing	Trinity Test Site, New Mexico	More than 1, less than 100
Plutonium processing	Rocky Flats, Colorado--offsite	3-5
Plutonium processing	Hanford, Washington--offsite	4
Plutonium processing	Savannah River, South Carolina--offsite	4
Plutonium processing	Mound Laboratory, Ohio--offsite	4
Strategic mission/nuclear weapons	Spain	Extensive cleanup carried out; amount is classified information
Strategic mission/nuclear weapons	Greenland	25 left, after extensive cleanup
Purposeful waste release	by UK into the Irish Sea	1500-2000 in sealed containers

* CURIE: the basic unit of radioactivity defined as the quantity of radioactive material giving 3.7×10^{10} disintegrations per second. A millicurie is $\frac{1}{1000}$ of a curie; a microcurie is $\frac{1}{1,000,000}$ of a curie.

** General weapons grade plutonium has the following approximate composition: plutonium-238, 0.01%; plutonium-239, 93.6%; plutonium-240, 5.9%; plutonium-241, 0.4%; plutonium-242, 0.04%; americium-241, 0.02%; RTG plutonium is largely plutonium-238.

TABLE 3

NOTABLE EVENTS AT RF[2]

Year(s)	Event	Radioactive Release* (curie)
1957	Plutonium fire	0.026
1969	Plutonium fire	0.00086
1959-69	Plutonium leakage from drum storage area	3.6 lost offsite
1973	Tritium incident	500-2000[10]
1974	Accidental direct plutonium release of untreated air	0.00093
TOTAL PLUTONIUM RELEASES 1953 to 1974 - - - - -		0.026 airborne 0.060 waterborne 0.026 fires 3-5 oil spill

* Prior to mid-1973 monitoring detected long-lived alpha emitters only. Since mid-1973 specific isotopes, such as plutonium-238, 239, and 240 have been monitored in environmental samples.

review, "background" soil activities resulting largely from weapons testing (see Table 2) range from 0.001-0.002 microcuries per square meter. Colorado's level has been determined to be 0.0018. Accumulations in the RF area range from 0.002-200: (a) areas within the plant boundary range from 200 to 0.002 and (b) some off-site areas (within one and one-half miles mostly due east) have accumulations as high as 0.25 microcuries per square meter[2].*

C. Physical Layout of the RFP Site:

The area of the RF plant site is approximately 12 square miles and is enclosed by a four-strand barbed wire stock fence.[2]

The production complex itself (security fenced area of 0.6 square mile) is surrounded by a large buffer zone. The Omnibus Assessment claims[2] that the buffer zone extends somewhat more to the east and southeast than in other directions thus offering "control of areas downstream and downwind of the Plant"[2] (Figure 1). It seems clear from the figure that the Plant is not to any significant degree better buffered to the east. Within the production complex (Figure 2) are more than ninety structures housing the plutonium fabrication, beryllium fabrication**, and uranium alloy fabrication facilities as well as various waste treatment, research, and administrative facilities. Plutonium recovery and process wastewater treatment facilities are under construction. A sanitary wastewater recycle system is in the planning stages and is scheduled to be completed in 1978. Completion of this system will give the RFP a completely self-contained wastewater facility; except for evaporation, no wastewater should leave the plant site.

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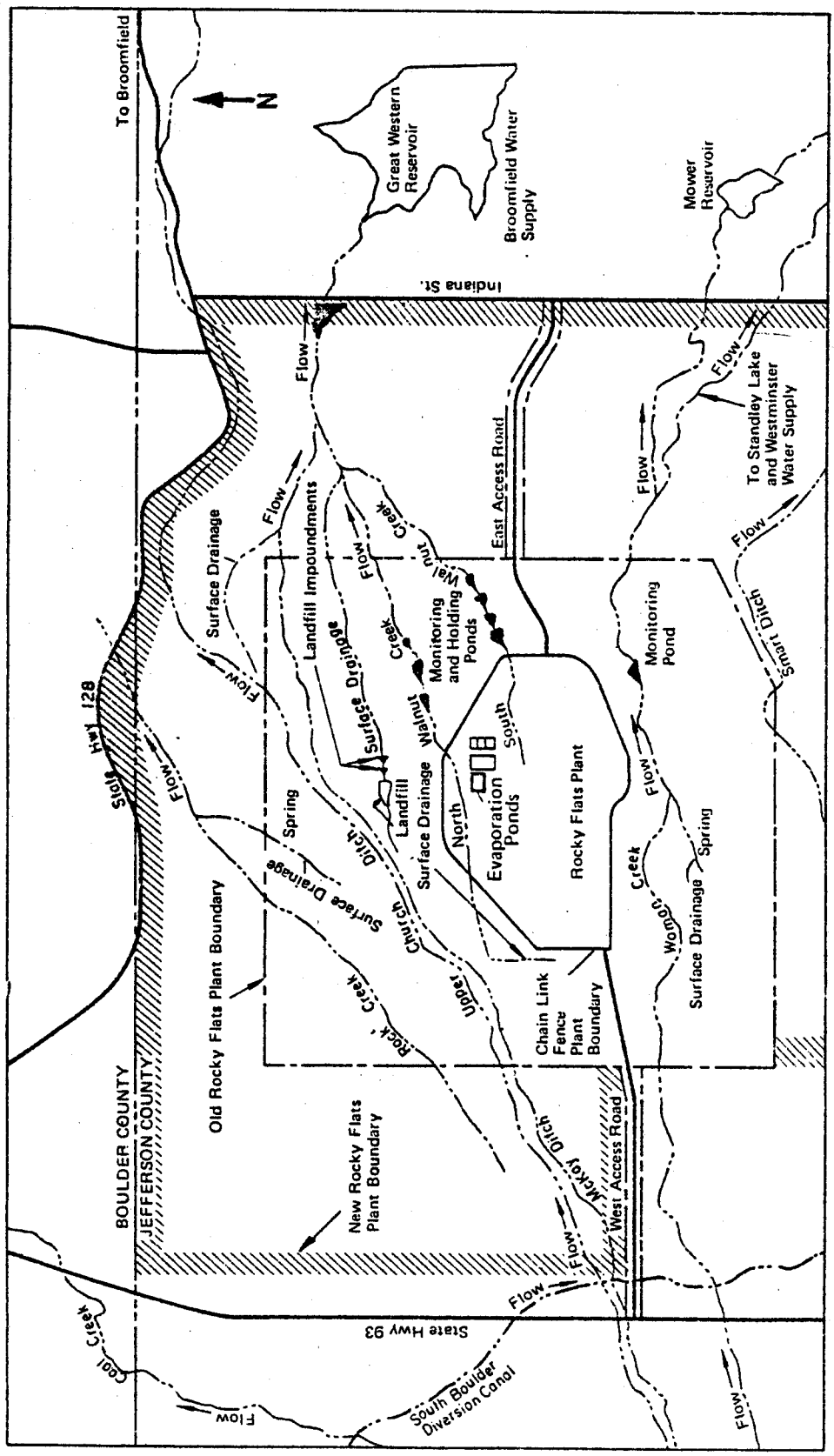
* The setting and application of various standards will be discussed in Chapter IV, Section A.

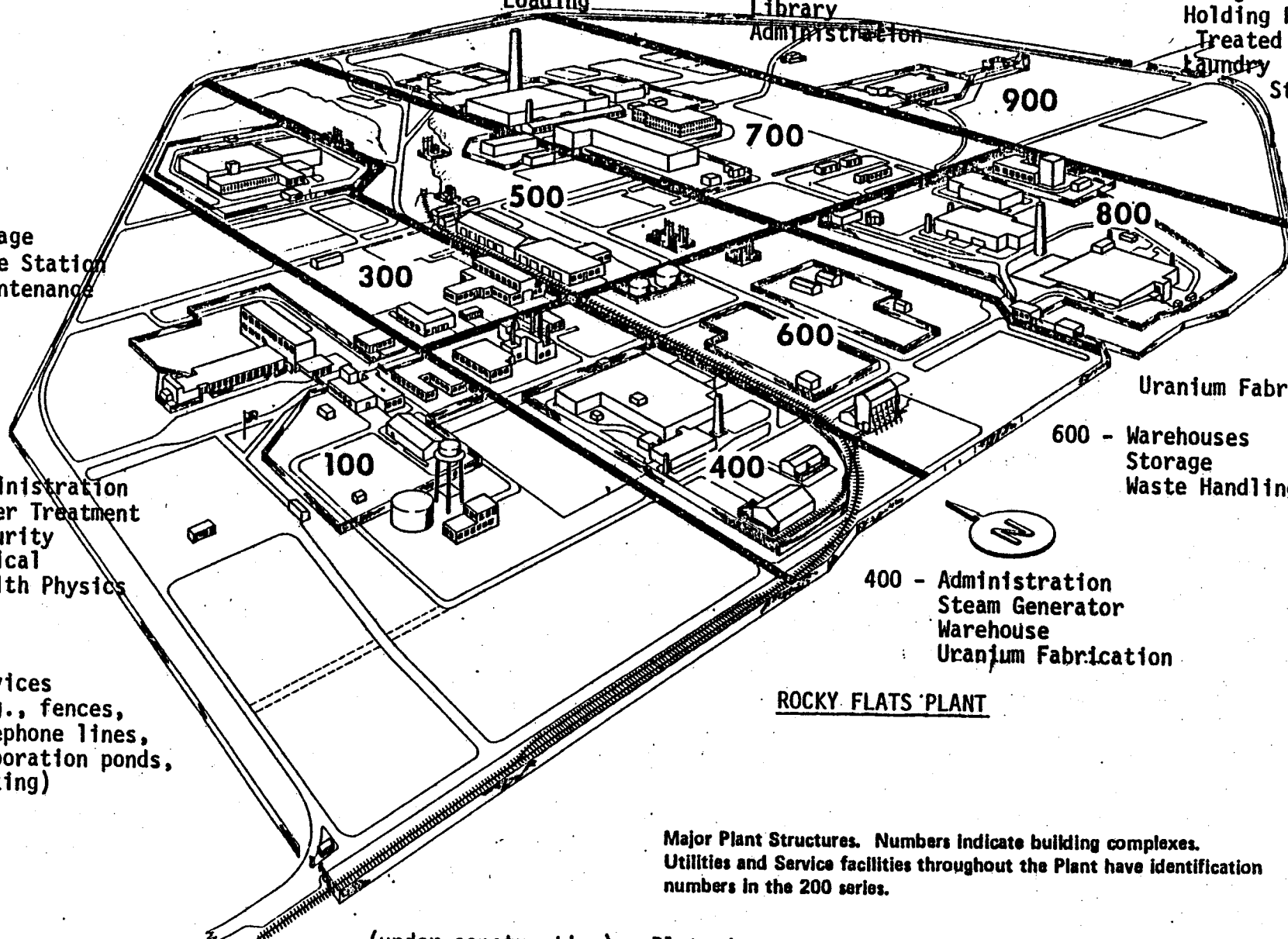
** Beryllium is used as a neutron source in nuclear devices.



Drainage Channels and Diversion Canals.

FIGURE 1.
Page 42 A

Figure 2.
PAGE 42 B



Major Plant Structures. Numbers indicate building complexes. Utilities and Service facilities throughout the Plant have identification numbers in the 200 series.

In this brief section we have tried to give the reader a sense of both the history and operation of the RFP, and its interrelation with other facilities. Many details will be supplied in subsequent sections as we explore the facility in more depth.

CHAPTER III

Hazards Associated with the Rocky Flats Plant

Introduction:

The various hazards associated with the RFP are both radioactive and nonradioactive in nature. In this chapter we consider these while in the following chapter consideration is given to their control. The radioactive hazards are a result of the handling and fabrication of plutonium, americium, uranium, and their compounds. Nonradioactive hazards result from machining and metallurigical operations on various materials including beryllium, stainless steel, aluminum, tantulum, titanium, tungsten, copper, cadmium, silver, gold, lead, nickel, and graphite. Further, large quantities of other chemicals (e.g., nitric acid and carbon tetrachloride) are used routinely and represent potential dangers. We will comment almost exclusively on the radioactive hazards at RF while indicating that the hazards resulting from the handling of other materials have been minimized by the adoption of extensive control measures. Our emphasis on the radioactive dangers issues from our belief that the public has greater fear and less understanding of radioactive materials and radiation. It should not, however, be inferred that the nonradioactive materials are less dangerous. A constant, thorough control operation for nonradioactive materials, similar to that in any chemical manufacturing plant, is necessary to prevent problems.

Much of the information reported in this and the following chapter is taken either from the Draft ERDA Omnibus Environmental Assessment of RF[2] or results from an extensive tour[12] of the RFP by the Task Force.

A. High Level Contamination.

(a) Previous Contamination

Table 3 in Chapter II indicates the levels of radioactive contamination caused by various events at the RFP. It is clear that during normal plant operations releases of radioactive materials to the environment are small. Several accidents have, however, resulted in larger insults to the environment. The two most serious of these are the long-term leakage of the barrel storage area resulting in about a 3.6 curie offsite plutonium waste release and an estimated 500-2000 curie tritium release in 1973. The latter resulted from tritium "mistakenly and unknowingly brought into the Plant during March, 1973 with a shipment of plutonium scrap destined for reprocessing"[2]. Both of these releases were initially reported by outside sources. Subsequently, programs were designed for either reduction or cessation of such releases.

In the case of the storage area leakage, which was only publicized when a study conducted by Martell[13] turned it up, the highly-contaminated land has been stabilized by overlaying with an asphalt pad; immediately adjacent land, still quite contaminated, but not to extremely high levels, has been stabilized by both a plant ground cover and, more recently, a soil retention blanket*[14]. Final treatment of the area to reduce radiation levels significantly will occur only after comments have been received by ERDA on a separate Environmental

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* The soil retention blanket was made necessary by the unfortunate and questionable use of defoliants in the early summer of 1975. For further information see the introduction to the report.

Assessment being prepared for cleanup of the spill.[15] The area is carefully monitored by RF and the Colorado Department of Health (CDH); the delay in the final disposition of the problem has been agreed to by both the CDH and the Task Force. Both felt that the situation in the area is and has been quite stable and that the comments on the Environmental Assessment might bring forth a superior plan for removal of the contamination. In lieu of that, the area will probably be cleaned up by removal of the contaminated soil.[16] The Task Force strongly believes that this insult to the environment was a result of poor management and decision making. That the leakage was discovered shortly after the area was used for storage, but that nothing was done about it for eight years, we find deplorable.

The tritium release began in April, 1973, was detected by the CDH shortly thereafter, and was reported to AEC-Dow on May 4, 1973.[10,17] The report was substantially ignored since the RFP claimed not to use significant quantities of tritium in any of its operations. On July 31, 1973 high levels again were reported although the CDH had some question about the validity of its tests for tritium. At another meeting at RFP on September 5, 1973 (attended again by CDH, RFP, and EPA officials) concern was again raised by the CDH, but this time the EPA decided to cross-check the Health Department results.[10] By September 14, EPA had verified the CDH's results; EPA and CDH concluded that the RFP was the only credible source of the tritium release. On September 26, AEC officials at the RFP accepted responsibility for the tritium leak. An AEC investigative report released on November 26, 1973 pieces together some of the story of the contamination. On March 19, 500-2000 curies of tritium (unknown to the RFP) arrived at the Plant from the Lawrence Livermore Laboratory. The tritium was associated with some scrap plutonium to be reprocessed. Between April 9 and 25 this scrap was chemically

treated as if it contained only scrap plutonium. As a result, no steps were taken to capture the tritium and it was lost to the liquid waste system. It has been estimated[10] that between 50-100 curies of tritium were released to waters eventually flowing into the Great Western Reservoir. Another indication of the spill comes from the CDH determinations of the tritium levels in the Broomfield water supply (these data have been routinely collected by the CDH) which peaked twice--in April and May of 1973. Following the second peak, an elevated but decreasing level of tritium remained in the water supply; it will require several years before the decreasing levels reach the natural background[10].

In contrast to the storage area leakage of plutonium wastes where measures were taken to stabilize the contaminated area, only time will bring about decontamination of the Great Western Reservoir*. The natural process of dilution of the water supply has fortunately reduced tritium concentrations in drinking water minimizing the dangers to Broomfield residents. EPA has carried out extensive calculations and estimations of the public health danger to drinkers of the Broomfield water supply. They have concluded that "any public health impact of this event is, therefore, expected to be minimal"[10]. (See Recommendation 2)

Additional releases, those of nonradioactive materials, have occurred. They resulted from cracks in the solar evaporating ponds used to concentrate liquid salt wastes. High concentrations of materials like nitrates have been released to the subsurface of the Plant site. Other potentially dangerous releases may occur through other tanks, piping, and solid waste burial sites[18]. No estimates of the extent of groundwater contamination have yet been made (see section on hydrology), but the RFP has begun[2] to monitor potentially dangerous sites of release.

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* Although we have indicated only the release of tritium to the Great Western Reservoir, it should be clear that other radioactive materials, particularly plutonium, have been released to the Reservoir in small quantities.

(b) Possible Contamination Resulting from Natural Catastrophe

The possibility that a natural disaster could release high level contamination has been studied in great detail since 1951. The original study[1] as well as subsequent studies conducted for the AEC (and ERDA) have indicated that the chances of a major natural catastrophe are remote. Some criticism of this conclusion has been leveled at RF and this will be discussed subsequently. In the brief sections below we will consider both the terrain, geology, hydrology, and meteorology of the RFP, as well as the potential for various types of natural disasters.

Gross Plant Site Terrain[2]:

The Plant is located on a level, rocky bench called Rocky Flats. At an elevation of about 6,000 feet, the plant rests on a stony soil consisting largely of "gravel and cobbles intermixed with sand, silt, and clay[2]". Some huge boulders break the monotony of this semi-arid bench.

Geology:

A detailed geologic study has been prepared for the RFP by J.A. Blume and Associates[2]. Most of the details of this study are of minor consequence for this report, but some controversy has arisen.[19] This results from an argument about when the last tectonic activity took place in this region. Tectonic activity (movements of the earth's crust) is closely associated with earthquake activity. The crux of the argument is that the Blume Study[2] would minimize the possibility of significant current earthquake activity while the critics[19] suggest that the possibility of severe activity in the RF region is not remote.

A detailed geologic study of the Plant site has recently been made to evaluate the area for construction of the plutonium recovery facility[2,20] (now under construction). According to ERDA[2], this facility has been maximally designed as a result of this study.

Hydrology:

Water flow through the RFP is largely from west to east. Figure 1 in Chapter II indicates the natural and man-made surface drainage in relation to the RFP. A long-range subsurface study by the U.S. Geological Survey, Water Resources Division, is in progress and should be completed by September, 1975. It appears at present that, although some information about the subsurface waters of the RFP is available, further details are essential to completely define the possibility of subsurface contamination. The results of the USGS report will, hopefully, supply the necessary information; we urge that all necessary steps be taken by the RFP to eliminate possible subsurface contamination.

Meteorology:

One of the most important cirteria for the original siting of the RFP[1] was a climate that was moderate and dry. Such is indeed the case with mean January and July temperatures of 30^{0} F and 72^{0} F respectively, a yearly average precipitation of about 15 inches, and an average relative humidity of 46%. Various extremes and averages of common meteorological data are presented in Table 4.

Wind direction, which is a primary concern in the dispersal of particulate contamination from the RFP, is predominately toward the east (i.e., a westerly wind). Average (17 years between 1953-1970) wind directions indicate

TABLE 4

AVERAGE AND EXTREME METEOROLOGICAL DATA

	Average	Extreme
Precipitation	About 15 inches/year	about 25 inches in 1969
Humidity	46%	60% in 1960
Temperature	77° F average maximum	102° F, July 12, 1971
	22° F average minimum	-26° F, January 12,1963
	50° F average mean	
Wind	8.1 mph average mean wind velocity	105 mph on four occasions

that "west winds occurred 25% of the time; over 50% of the winds had a westerly component."[2]

Tornadoes:

Tornadoes of dangerous magnitude occur rarely in central Colorado. In fact, as you proceed west from the Colorado border the frequency and severity of tornadoes decreases. These were important considerations in the original siting of the plant[1]. Further, the proximity of the RFP to the mountains tempers the severity of tornadoes. There are no reported cases of tornadoes just east of the Rocky Mountains having winds in excess of 200 mph. Such winds would be 100 mph less than those characterizing some midwestern tornadoes.[2]

Earthquakes:

As a result of the controversy surrounding the geologic studies of the RF region, it is not surprising to find dispute over the possibility of a major earthquake near RF. The Draft Omnibus Assessment[2] asserts that both the historic earthquake record and the lack of recent tectonic activity mitigate against the possibility of a major quake. Matthews[19], on the other hand, states that recent seismic activity is demonstrable and that such activity is more important as a warning for future earthquakes than the historic record. Several additional sources consulted by the Task Force[20,21] indicate that the potential for a major earthquake is remote.

(c) Possible Contamination Resulting from Accidents

Fires have plagued the RFP since its beginning largely because of the pyrophoric (igniting spontaneously) nature of plutonium and some of its compounds. Fire danger is minimized by handling plutonium materials under an

inert atmosphere of nitrogen gas containing a few percent of oxygen. Increasing or decreasing the amount of oxygen increases the potential for ignition. In both the 1957 and 1969 fires plutonium was released to the atmosphere: the earlier fire was severe enough to breach the filter systems to the environment; the 1969 fire although very costly* was less severe with atmospheric release resulting from the breaching of a room air exhaust filter and the tracking about of plutonium by the firemen. The danger of future fires is real, but as we will discuss, the technological advances in prevention and containment reduce the possibility of major contamination.

The dangers of a criticality accident ("sustained nuclear chain reaction"[2]) or a nuclear excursion ("sudden, rapid rise in the power level for a massed fissile material"[2]) are real when large quantities of pure fissionable material are handled. Such accidents can result from close packing of such materials with the geometry and density of material being important controlling factors. No criticallity accident or excursion has ever been reported at the RFP. Research criticality studies have been carried out; these, we are told by the RFP[22], are carried out under precisely controlled, safe conditions.

The Task Force has worried a great deal about the possibility of a contaminative release caused by mechanical failures or sabotage. Among the accidents which we feel are credible are: (1) an airplane crash into the plutonium facility at RF, (2) a transportation accident involving truck shipment of weapons grade material or railway or truck shipments of various waste materials, or, (3) various acts of terrorism or sabotage. It is impossible to predict the probability of such accidents yet important to point out that they

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* Approximately $26,000,000 was spent in the aftermath of the 1969 fire[2] to affect repairs, study the causes of the fire, and institute necessary precautions against future problems.

are possible and that every precaution be taken to avoid any insult to the environment resulting from them.

B. Low Level Contamination

The possible events just described in Section A are less likely to release high levels of contamination than low levels and should be taken as a signal to regard the possibility of low level contamination seriously. Low level contamination is mysterious and subtle since, as we will soon point out, its long-term effects on animals and man are unknown. The Task Force takes the position that the limits to be placed on radioactive release should approach zero as closely as can be attained at any given stage of technological advancement. This is an evolutionary concept since as technology advances, releases should more closely approach zero. The factors leading to this are basically three: (1) that we know little or nothing about long-term radiation effects, (2) that until we do, levels should be as low as possible, and (3) that virtually all standards set for radioactivity have had to be lowered as the effects of the radioactivity have become better understood and as our techniques of measurement have become more sophisticated. Our position differs from that of ERDA who attach the proviso of economic feasibility to the lowest possible level at a given technological stage.

CHAPTER IV

Control of Hazards at the Rocky Flats Plant

Introduction:

In this chapter we discuss the application of radioactive standards to the RFP and its environs as well as the measures taken at RF to secure the control of its potential hazards.

A. Radioactivity Standards:

Because of the potential danger resulting from release of radioactive materials from the RFP, an extensive monitoring program is carried out by the RFP and the CDH. Monitoring of air, water, and soil samples must be performed routinely to determine the radiation impact on the area. Standards for air, water, and soil monitoring, as well as for occupationally exposed workers and the general public have been developed to minimize the occurrence of possibly harmful effects of exposure to radioactive materials. Monthly meetings attended by the RFP, CDH, EPA, City of Broomfield, City and County of Boulder, Jefferson County, and interested observers are held to review monitoring data and discuss other aspects of the RFP operation.

Recommending standards for radioactive materials is a complicated task[23,24,25,26]. The greater our knowledge of the material, the better standard can be set. Yet our knowledge is in only a rudimentary stage with respect to "correct" standards. It is a matter of philosophical commitment[26] among the groups*

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* The International Commission on Radiological Protection (ICRP) and the National Council on Radiation Protection and Measurements (NCRP) are the oldest and best known radiation standard recommending groups. Both have maintained continuous studies of radiation protection problems since their inception. In general both bodies have recommended similar radiation standards.

who recommend standards that maximum protection be afforded those who contact radioactive substances. As a result such groups always attempt to overestimate the dangers known at the time. Nevertheless, virtually every standard recommended for radioactive materials has been reduced as more information accrued.

Standards can be divided into two classes:[23,24,25,26] (1) primary standards which are applicable to all radioactive substances and sources and (2) derived standards which refer to a specific radioactive material. One can further delineate not only between the effects of radioactive whole body and critical body organ exposure, but also between the exposure limits to the general population and to occupationally exposed workers.

Let us first consider definitions of the common basic radioactive units:

(1) Rad: a rad (radiation absorbed dose) is a quantity of energy absorbed from a radioactive source; specifically, one rad is the amount of radiation required to cause absorption of 100 ergs of energy per gram of absorbing target[24].

(2) Rem: a rem is a quantity of equivalent dose; specifically, one rem is the quantity of any type of radiation which, when absorbed in man, produces an effect equivalent to the absorption of a rad of X- or gamma radiation[23].

We must be clear on the difference between a rad and a rem. When two different types of radiation* deliver the same amount of energy to a target, different

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* Radioactive materials emit different types of radiation characterized by different energies and different penetrating powers. Alpha radiation, the type given off by most plutonium isotopes, is characterized by its poor penetration into targets. Beta, gamma, and X-rays penetrate deeper into targets than alpha radiation. Alpha radiation can present internal hazard to the body where the beta, gamma, and X-rays generally are considered a hazard external to the body.

amounts of damage may be done. The rad allows us to express the amount of energy reaching the target; the rem gives us a way of estimating the damage done. A dose of one rad of fast neutrons does ten times the damage of one rad of X-rays[27] (e.g., one rad of X-rays equals one rem, but one rad of fast neutrons delivers ten rems to the target.) We can express this as follows realizing that the quality factor (QF) is the modifying factor accounting for different biological effects from equivalent energy quantities of different sources of radiation:

Dose Equivalent (in rems) = QF x Dose (in rads)

Since one of our purposes in this report is to assess the biological dangers associated with the RFP, we will be concerned only with equivalent (or rem) doses. Also, we will primarily be concerned with alpha radiation from plutonium, americium, and/or uranium sources. Alpha particles have QF's of ten relative to X- or gamma rays. That is, alphas are ten times more damaging to target (biological) materials than X- or gamma rays.

A further important point is based on consideration of the target. Radiation doses can be expressed as whole body burdens or as critical organ burdens. Various target or critical organs have different responses to alpha radiation; some are extremely sensitive while others appear practically unaffected. To critically and properly assess burdens to various organs, a great deal of information must be known. For instance, the quantity and distribution of the radiation must be ascertained. In general, radiation impinging on the surface of a biological target will affect the skin while radiation reaching an internal target (either by inhalation, ingestion, or some other insult to the organism by a radiation releasing substance) will be distributed to the internal organs. It is a prodigious task to study the distribution of radioactivity within a complex organism. Not only are there numerous variables

to be studied (e.g., mode of entry of radiation, chemical form of radioactive substance, isotopic distribution of radioactive material, etc.) but ultimately the animal must be sacrificed and each of its organs assayed for radioactivity. If this were accomplished with certain animals, its applicability to the human animal would still have to be studied requiring comprehensive autopsy data on a very large number of individuals.

With this brief discussion we hope it is clear that the recommendation of radiation standards is exceedingly difficult. Because complete data does not exist and since obtaining some of these data will be both difficult and time consuming, we are faced with standards that are little more than crude estimates of the hazard limits. This is not meant as a criticism of those who recommend standards for they continually warn us:

> "all NCRP reports tend to contain pragmatic recommendations based on reasonable interpretations of available but usually incomplete scientific data"[26]

> "because the criteria involve value judgments on matters that potentially affect the welfare of future generations as well as of living individuals, ultimate acceptability of the criteria also rests with society as a whole, rather than with any member or group"[26]

To gain some perspective of the radiation doses discussed in this report, let us consider the radiation sources that we commonly meet in everyday life. The radiation doses arising from external sources such as cosmic radiation or gamma and alpha rays from materials in the soil vary with location[26]. Cosmic radiation doses are greater at higher elevations so that the Denver population receives about 0.07 rem per year compared to a U.S. average of about 0.04 rem/year.

The average terrestrial radiation dose (from naturally occurring radioactive materials in soils and building materials) received in the U.S. is 0.06 rem per year, but in Denver it is estimated to be 0.09 rem per year.[28] Other sources to be included in the total "everyday" dose are ingested food, water, and air, and diagnostic and therapeutic medical sources. Estimates of these are presented in Table 5. We estimate[26,28] that the total "everyday" exposure received by a typical Denver resident is 0.25 rem per year compared with the U.S. average of about 0.20 rem per year. Thus an average Denver resident receives roughly 25% larger radiation dose than the average non-Coloradoan; in addition Colorado receives the highest external radiation dose of any state.

Primary standards of radiation dose to the whole body have been suggested by NCRP[26] to not exceed 0.17 rem per year* for the general public and 5 rem per year* for occupationally exposed workers. The Colorado Department of Health has adopted[29] these standards; the ERDA regulations developed from ICRP and NCRP recommendations differ only slightly from the CDH. Other CDH and NCRP standards are listed in Table 6.

The various critical organ burdens are estimated both from biological models of radiation dispersal and from experiences with exposures of these organs. It is essential again to emphasize that the derivation of primary standards is very crude indeed. We assume, but are not sure, that primary standards have been set at low enough levels.

Derived standards, those applicable to specific radioactive materials, are even more elusive. Table 7 lists some of the air, water, and soil standards applicable to this report. These standards are derived in such a way that exposures of either workers or the general public to these specific radiation sources will not exceed the primary standards listed in Table 6. For plutonium

* These doses are in addition to the background ("everyday") dose.

TABLE 5

"Everyday" Doses of Radiation[26,28]

Source	Estimated Dose (in rem/year)
Cosmic rays	0.04 average United States
	0.075 Denver, Colorado
Terrestrial	0.03 Dallas, Texas
	0.09 Denver, Colorado
	0.06 average United States
Uptake of food, air, and water	0.025 average U.S. - Internal dose
Medical uses	0.06 average United States

TABLE 6

CDH[29] and NCRP[26] Standards for Radiation Dose*

	CDH (rem/year)	NCRP (rem/year)
Whole Body (Occupational Exposure)	5	5
Whole Body (General Population)	0.17	0.17
Skin (Occupational Exposure)	30	15
Hand (Occupational Exposure)	**	75
Forearms (Occupational Exposure)	**	30
All other tissues, organs, and organ systems (Occupationally Exposed)	- - -	15
All other tissues, organs, and organ systems (General Population)	0.17	0.17

* A number of more specific standards apply to workers who have large doses, are pregnant, or are younger than 18 years of age. Consult Reference 26 and/or 29.

** CDH combines hands, forearms, feet, and ankles together with a limit of 75 rem/year. The CDH regulations are patterned after those suggested by the Nuclear Regulatory Commission (NRC).

TABLE 7

Derived Standards Pertinent to the RFP

	CDH[29]	ERDA	(Units)
Water			
Plutonium-239 + 240 (General Population)	1600	1667	(times 10^{-9} microcuries per milliliter)
Tritium (General Population)	1,000,000	1,000,000	(times 10^{-9} microcuries per milliliter)
Air			
Plutonium 239 + 240 (MPBB) (Whole Body)	0.04	0.04	(microcuries)
Plutonium 239 + 240 (MPLB) (Lung)	0.016	0.016	(microcuries)
Plutonium 239 + 240 (Occupational Exposure)	2	2	(times 10^{-12} microcuries per milliliter)
Plutonium 239 + 240 (General Population)	0.02	0.02	(times 10^{-12} microcuries per milliliter)
Soil			
Plutonium	2*	- - -	(disintegrations per minute per gram)

* See discussion in Chapter VI, Section G.

and other radioactive materials derivation of such standards requires a knowledge as yet incomplete. The standards listed in Table 7 are, as a result, very crudely derived.

One last comment on standards. It is clear that allowed levels of exposure for occupationally exposed workers are greater than for the public. This is considered to be justified because of the careful monitoring control of such workers and the required nature of their medical regimen. Further, many workers, ERDA, and the standard recommending groups feel that a slightly increased risk is outweighed by the importance of the tasks occupationally exposed workers are engaged in. (See Recommendation 11 A)

B. Industrial Safety*

The RFP has had an excellent record in industrial safety* despite its size, complexity, and the danger of some of its operations. The personal safety record of the RFP employees "ranks first among major industries in Colorado."[2]

C. Security and Safeguards

The RFP is secured by two main gates as well as complete security fencing. Armed guards man the gates and patrol the Plant site. An intricate security system is evident within the site allowing only cleared people into various areas. A tag worn by every person onsite designates what area(s) he or she is allowed in[12].

The Task Force, nevertheless, registers its concerns about security. Recognizing that a great deal of publicity has recently been given to security

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* We are distinguishing here between industrial and radiation safety.

in various nuclear facilities and that some measures have been taken to alleviate problems, we tend to believe that anyone wanting to gain access to the RFP could.

Safeguards are perhaps best described as the measures necessary for complete inventory and protection of nuclear materials. Elaborate and, we believe, safe measures are taken for both the shipment of incoming radioactive "raw materials" and outgoing processed material. Such materials are transported in specially designed courier-attended trucks. Details about both the trucks and the actual movements of materials are difficult to obtain because of their necessarily secret nature. We are assured that every possible precaution is being taken.

On the other hand, inventory of nuclear materials within the RFP is difficult for the Task Force to assess. Extensive measures are taken to monitor work areas, waste process materials, and outgoing processed materials, yet the Task Force has no indication or expertise to determine how closely the material balance of radioactive materials is or can be kept. Again, we are concerned, largely for two reasons: (1) that various amounts of such materials might be stolen, or (2) that amounts might be accidentally dispersed. (See Recommendation 3 B)

D. Emergency Response

A system of emergency responses exists allowing reaction to numerous conceivable emergencies both on- and offsite."These include radiological, operational, natural, civil, and National disasters or emergencies."[2] Listed below are some of the local responses looked into by the Task Force:

(1) RFP Medical Department)
) These both appear to the Task Force to be adequate in response to many emergencies.
(2) RFP Fire Department) We find it impossible to assess their adequacy in responding to a major accident.

(3) St. Lukes Hospital - an agreement between the RFP and St. Lukes provides RF with trained medical personnel and the facilities to respond to a radiation accident--a mock accident recently was staged at St. Lukes.

(4) Colorado General Hospital - an agreement similar to that with St. Lukes is pending.

There are both written and informal plans covering all types of emergencies; these have been considered in detail in the ERDA Draft Assessment[2]. Included within the response system is the Colorado Emergency Response Plan coordinated and controlled by the Colorado Department of Military Affairs with the cooperation of the CDH. Without detailing the cooperative efforts leading to these plans, we assert that the coordination and planning are reassuring to the Task Force. We, however, worry about the continued readiness of all the components in the system believing that extensive mock disaster training is a necessity. We hope it will be faithfully and routinely carried out. (See Recommendations 10 A-D)(14 A-D). (See Chapter VI, Section F).

E. Removal of Lip Contamination

Discussed in Chapter III, Section A

F. Purchase of Surrounding Land

The RFP is buffered from its neighbors by large expanses of Government owned land. Recently this buffer zone has been increased (see Figure 1) by the acquisition of 4,000 acres of land. This newly-acquired land will serve only as a buffer; there are no plans to expand the plant into this area[2]. (See Recommendation 9 A)

G. Monitoring of Dangerous Materials

Both the RFP and the CDH extensively monitor both radioactive and non-radioactive materials. RF monitors ambient and effluent stack air, ambient and effluent water, soil, and its workers on the Plant site; the CDH not only carries out onsite data acquisition, but has an extensive offsite program. Table 8 lists some of the routine analyses carried out by the RFP and/or CDH.

Figures 3 and 4 indicate where air sampling is conducted. To avoid a long discussion of the actual monitoring data, we would indicate that the CDH serves as an important watchdog of the data. Actual values are almost always far below accepted standards. Even at below standard levels, the CDH views any increasing trends with alarm. The Task Force commends not only this attitude, but the harmony with which the CDH and the RFP interact.

Finally, let us consider the monitoring of the RFP workers. Every employee wears a radiation sensitive badge capable of detecting external radiation. These badges are sensitive to all radiation types except alpha. Radiation results are reported in rem units; no RF worker has ever exceeded his or her standard limit by any external exposure according to the RFP[2]. The Task Force has voiced concern[12] that these radiation exposures are not vigorously and meaningfully disseminated to the workers; we have been assured[31] that the new Rockwell management will vigorously pursue a radiation safety awareness program. We are further concerned about the sensitivity of the badges and the procedures used to test the badges.

Internal exposures of workers are routinely monitored for plutonium by urine bioassay and by lung counting procedures. These analyses are somewhat complementary, the former allowing analysis from a known single occurrence and the

TABLE 8

Routine Analyses on RF Materials[2,30]

Ambient monitoring of water:

(a) Nonradioactive

dissolved oxygen
residual chlorine
fecal coliform bacteria
sulfates
chloride
cyanide
fluoride
arsenic
beryllium
chromium
selenium
zinc
nitrate
phosphate
pH
phenolics

(b) Radioactive

plutonium
uranium
americium
total alpha radiation
total beta radiation
gamma radiation
tritium
strontium

Ambient monitoring of air:

(a) Nonradioactive

beryllium

(b) Radioactive

tritium
uranium
plutonium
americium
total long-lived alpha and beta radiation

Ambient monitoring of soil:

plutonium
americium
uranium
beryllium

Effluent monitoring of water:

(a) Nonradioactive

ammonia
bacteria
chromium
beryllium
pH
phosphate
nitrate
BOD (biological oxygen demand)

(b) Radioactive

total alpha and beta radiation
tritium
strontium
plutonium
gamma radiation

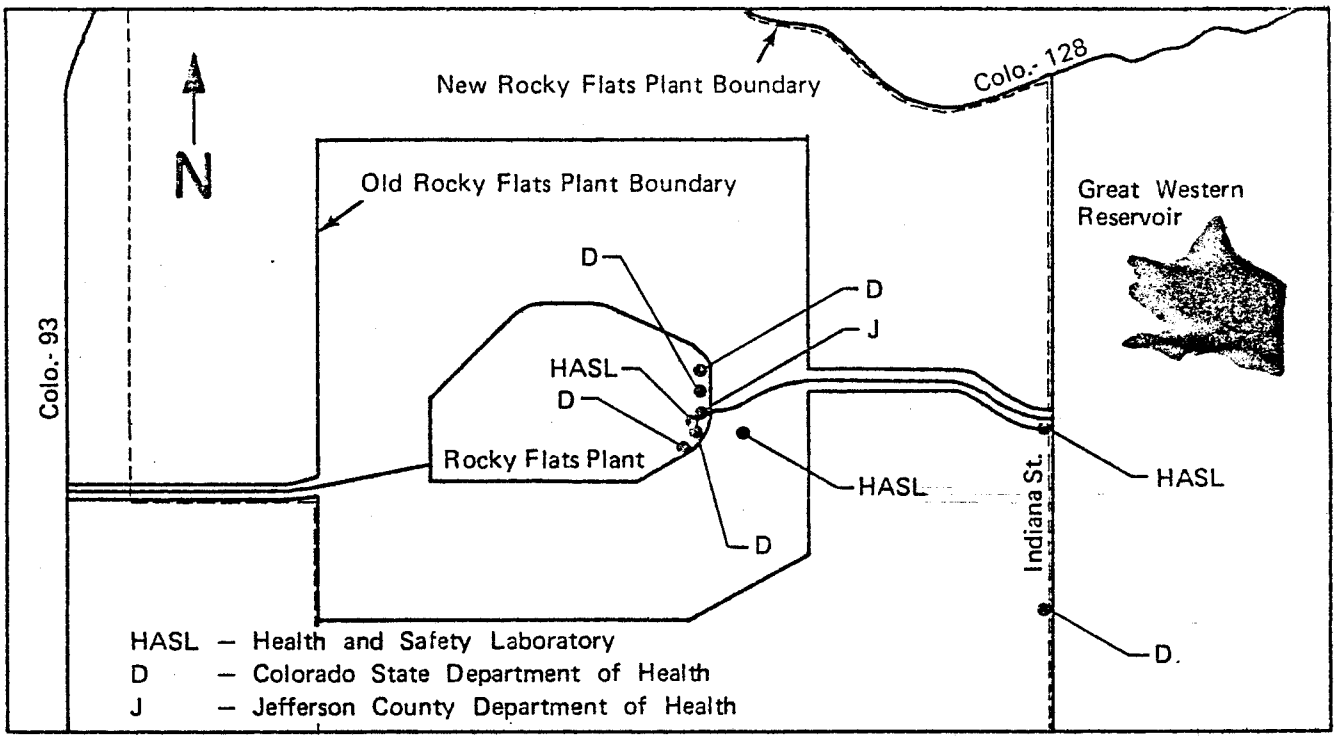
Effluent monitoring of air:

(a) Nonradioactive

beryllium

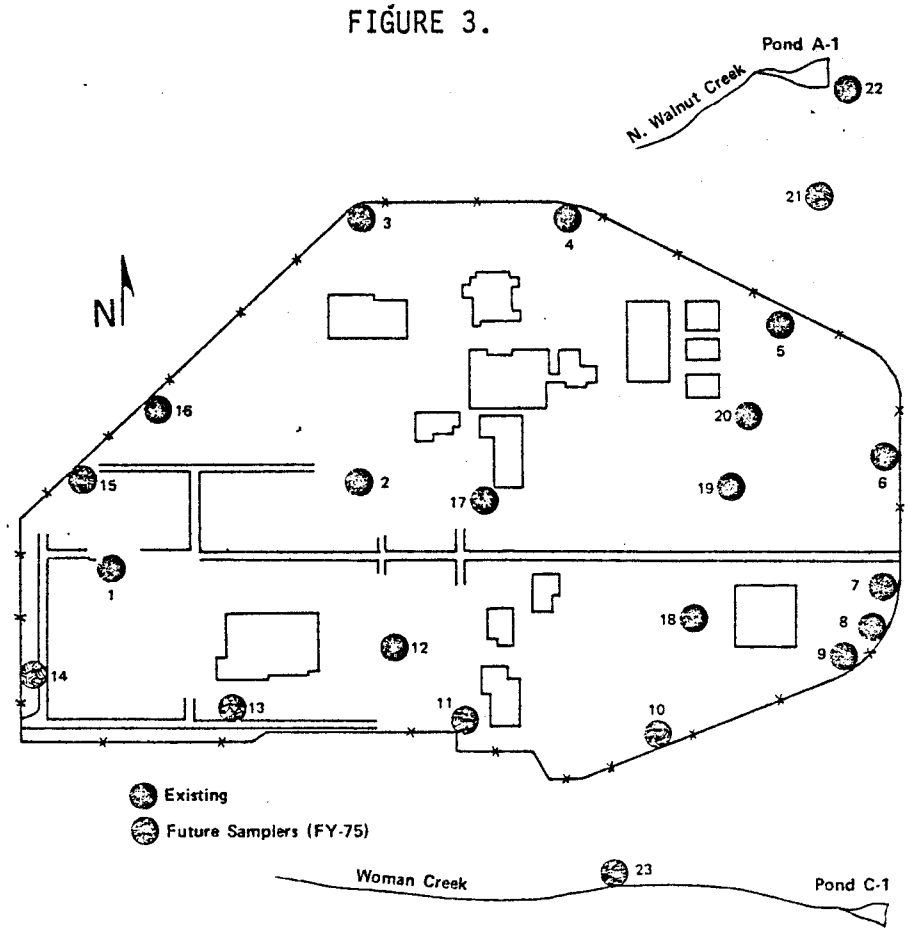
(b) Radioactive

tritium
plutonium
long-lived alpha radiation
uranium



Air Samplers Operated by Independent Agencies.

FIGURE 3.



On-Site Air Sampling Stations.

FIGURE 4.

latter from a long internal exposure. Current employees working with plutonium are on a mandatory monitoring program while former employees who have accumulated large body burdens are able to return to RF for periodic checks. Only a few former workers have returned for checks. The Task Force believes a more vigorous effort should be made to insure that such former employees are encouraged to return for checkups.

The lung counting instrumentation at RF is quite sophisticated. The Health Physics Department at RF seems to be vigorously attempting to obtain the best counters available. They are hoping shortly to have on-line a system as good as any now existing in the world--one having detection limits that are one-tenth (0.1) the maximum permissible lung burden of plutonium[12,31]. Various authorities[32] disagree strongly stating that with present technology reaching 0.25 of the MPLB would even be extremely difficult. Present instrumentation at the RFP cannot detect lung burdens of less than one maximum permissible lung burden. (See Recommendation 7 A, 7 I, and 7 J).

H. Other Safety Measures at the RFP

(a) Building Design

All buildings where plutonium materials are handled are of special design. The most important design criterion calls for containment and control of radioactive materials[2,12]. Most plutonium manipulations (all the hazardous ones) are carried out in glove boxes (containers in which dangerous materials can be manipulated under an inert atmosphere) and attached to an extensive filter system (see below). Containment is made possible by controlling the relative pressures in the corridors, the work areas, and the glove boxes: the highest pressure is in the corridors, next highest in the work areas, and the lowest in the glove boxes.

All pressures in these structures are less than the outside pressure. Should any of these areas suffer a breach to the environment, the natural flow of dangerous materials would be toward the glove box system. As a result the outside atmosphere should remain clean unless the filter systems fail. In two recent accidents, July 30 and 31, 1975, gloves in the plutonium recovery area glove boxes were broken. One worker in each accident received both skin and inhalation contamination. The cause of these accidents has yet to be made public. The Task Force registers its concern that even with the sophisticated design in these areas, workers still could become contaminated.

Newly planned facilities are designed to withstand major catastrophies without the possibility of dangerous releases to the atmosphere[2]. For example, the plutonium recovery facility now under construction will be able to withstand 300 mph tangential winds without damage[2]. The Task Force, however, is skeptical that the roof of such a facility could withstand a major aircraft crash. (See Recommendation 6 A, 8 B, 10 D, 11 B).

(b) Safety Features in the Buildings

The glove box areas have been fitted with water sprinkler systems to deal with the potential from spontaneous ignition of plutonium materials. In the past there has been some reluctance to fight plutonium fires with water because of the danger of a criticality accident. Experience with the 1969 fire has indicated that water is a very effective firefighter and that a critical accident is a remote possibility[33]. Also as a result of the 1969 fire smaller quantities of plutonium are allowed in production lines[33].

Very large numbers of special filters are used at RF both in individual respirators and as effluent filters in areas potentially releasing dangerous

materials to the atmosphere. An extensive program at RF checks every filter to be used to determine whether it meets specifications. Banks of high efficiency particulate air (HEPA) filters are placed at the extremity of the glove box systems reducing significantly any atmospheric release. The Task Force has studied the recent literature on HEPA filters concerned about just how efficient they might be. In particular, one recent study[34] subjects HEPA filters to the flow of plutonium particles. The plutonium particle size was varied as were flow rates, numbers of HEPA filters, and types of HEPA filters. The study was somewhat limited because of technological problems; particles of very small size are at present impossible to produce although these are believed to be the extremely dangerous ones when retained in the lungs[35]. Every variation performed on the HEPA systems[34] resulted in efficiencies greater than 99.97% thus satisfying the minimum efficiency criterion imposed on HEPA filters of the types used at RF. Efforts are being made to study smaller particle sizes. The Task Force recognizes the technical problems at hand, but voices its concern that no such data are yet available. We urge that greater resources be made available to examine this problem as well as its relationship to lung burdens and disease. We further urge that studies be instituted to ascertain the nature and characteristics of the effluents which do get through the HEPA banks. (See Recommendations 11 B, D, and E).

The RFP takes great care in the storage of fissionable (usually called fissile) materials. Two concerns are important: (1) elimination of the possibility of a critical accident, and (2) elimination of the possibility of the material being stolen. "Most storage facilities are walk-in vaults in which fissile material is stored in shipping containers or in fixed positions on

shelves or racks."[2] A program at RF has been initiated to store all fissile materials in storage inerted vaults and to move the material by remote control devices. A great deal of care is evident on the part of the RFP to avoid the potential problems of storage of large quantities of fissile materials.

(c) Waste Handling

A plant the size of the RFP produces large quantities of waste of several types: (1)sanitary--liquid and solid, (2) process--liquid and solid, and (3) miscellaneous wastes. From 1952-69 a number of sites at RF were used for disposal[2]. In these, massive quantities of depleted uranium have been buried in drums and covered with fill dirt. Also, other large quantities of depleted uranium and small amounts of plutonium have been buried onsite. Since 1968 approximately 0.001-0.002 curies of alpha radioactivity have been buried as sanitary sewage sludge[2]. There are at present no plans to disturb any of these sites, but the Rockwell management indicates[31] that they will review the subject. The present uncertainties with respect to subsurface water flow on the RF site suggests to the Task Force that the review should be expeditiously carried out and the decision re-evaluated through a separate EIS. Rockwell plans no burial of wastes on the RFP site. (See Recommendation 12 B)

Liquid wastes at the RFP are handled in several ways. Liquids contaminated with plutonium are treated in a process waste treatment plant. Here plutonium and "other chemical contaminants"[2] are reduced in volume and converted to solid waste for shipment to ERDA approved offsite storage areas. Other liquids with large amounts of chemical contaminants, but low levels of radioactivity, are reduced in volume in solar evaporation ponds[2]. Salts produced on

evaporation are packaged in drums and removed offsite. Since December, 1973 there has been no release of process wastewater. It is being retained in a large holding pond awaiting completion of the new waste treatment facility.

A few words about the present transportation of solids offsite[36] are necessary. All radioactive materials removed from the RFP are either packaged in heavy gauge drums or large polyester-coated wooden containers. The material to be shipped in drums is: (1) packaged in a plastic bag, (2) surrounded by a polyethylene liner, (3) sealed within a molded polyethylene container in the heavy gauge 55 gallon drum, (4) placed in a cargo carrier container, and (5) loaded on a ATMX railroad car*. The wooden containers are as carefully shipped as are wastes containing lower level radioactive wastes. All shipments of hazardous materials both in and out of the Plant are controlled by regulations of the U.S. Department of Transportation. The Plant indicates that these regulations are strictly** adherred to and the Task Force has been impressed by the care taken in packaging and transportation of waste materials. A note of concern, however, is that massive quantities of waste materials leave the RFP (and other locations) and are shipped to a temporary storage facility in Arco, Idaho. We urge that ERDA find a permanent site of requisite size and safety. (See Recommendation 8 C)

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* The letters, if said fast enough, come out atomics (Army Transport Model Special). These are specially designed railroad cars for shipping explosives or radioactive materials.

** We have recently investigated[37] what measures the U.S. Department of Transportation takes to be assured that its regulations are being met. We found that at present these were essentially nonexistent although new legislation has been enacted to give the Department both more authority and resources to carry out this function. It was stated[37] that facilities like the RFP are in general extremely good about meeting the regulations.

Sanitary wastes at the RFP are of very low radioactivity and are treated completely separate from process or industrial wastes. At present sanitary wastes are treated at a sewage treatment plant, sent through a series of waste holding ponds, and finally released to Walnut Creek and the Great Western Reservoir. Plans have been made for an addition to the present sanitary waste treatment plant. Expectations are[36] that construction of the addition will begin in 1977 with completion toward the end of 1978. Upon completion RFP will have a completely closed wastewater system (both process and sanitary); the only loses to the environment should be through evaporation.

CHAPTER V

Biological and Medical Aspects of Plutonium

Introduction:

The potential hazards of plutonium and its compounds have been indicated repeatedly. In this chapter we try to assess these by highlighting some of the biological research carried out with plutonium materials. As expected in such a new field, although the desire to understand the biological effects of plutonium materials is great, our fundamental understanding is still rudimentary. In this chapter we will be almost exclusively concerned with those plutonium materials used at RF. These include plutonium metal, plutonium oxide, and solutions of plutonium nitrate. It is essential to emphasize both that very little experimental work with plutonium materials has been carried out on human subjects and that there is always a question about the application of the results of animal studies to humans. Further we will consider almost exclusively somatic effects (changes to the body caused in the present generation) since virtually nothing is known about the genetic effects of plutonium exposure.

A. Further Information on Plutonium

(a) Alpha Radiation

We have indicated that plutonium-239 is an alpha emitter. Alpha emission radiates over a short range. Physiological effects can only occur in the immediate vicinity of alpha emitters. Thus only "intimate and prolonged contact with human tissues"[7] represents a hazard to health. The dangers associated with various quantities of material in such contacts is still in question though the

raditoxicity of alpha emitters, plutonium in particular[38], is not[7,8].

(b) Isotopes of Plutonium

Plutonium-239 is the most abundant isotope in weapons grade plutonium (about 92% by weight) and represents to the locale of RF a major potential danger*. Other isotopes, particularly plutonium-238, are also commonly in use (See Table 2 in Chapter II). Although the 238 and 239 isotopes behave very differently in biological studies, we will focus our attention on 239 studies because of their direct bearing on the RFP.

(c) Important Plutonium Materials at the RFP

Plutonium metal, plutonium oxide, and plutonium nitrate are the most likely materials to affect the environment around the RFP. Plutonium metal, handled in large quantities at the RFP, is readily converted to plutonium oxide both by spontaneous ignition and by controlled oxidation. While the metal is perhaps best characterized by its high chemical reactivity, plutonium oxide is quite inert. Its insolubility and inertness are extremely important in biological experiments as we will see. Solutions of plutonium in nitric acid give rise to what are presumed to be plutonium nitrate solutions. In this chapter we will consider experiments in which plutonium nitrate is administered because (1) large quantities of plutonium are handled in nitric acid solutions at the RFP and (2) there is a fairly high potential risk to workers exposed to such solutions.

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* In Chapter 2, Section B, we briefly indicated that americium-241 is also a major potential danger. Although for simplicity we have not included very much information about americium in this report, again we emphasize that no one should underestimate its potential hazard.

(d) Plutonium Particle Sizes

Solid plutonium materials come in all sizes and shapes. It is important to understand that the sizes of plutonium materials are operationally defined with monomeric particles considered to be "very small" and polymeric considered to be "intermediate"* in size. Monomeric and polymeric plutonium materials entering the body are believed to be distributed differently with the monomeric particles being more evenly dispersed[39]. There is consensus that one of the potential dangers to health comes from particles of respirable size[40]. Respirable particles are quite small although their exact size remains a matter of some controversy.

(e) The Hot Particle Theory

Not only is there controversy over what respirable particle sizes do the greatest potential damage, but also by what mode of distribution within lungs the greatest potential damage can occur. Basically there are those[23] who are concerned that hot particles lodge in lung tissue and irradiate surrounding tissue at a greater rate causing a more serious potential for damage. On the other hand there are those who believe that inhaled plutonium particles can be thought to be fairly evenly distributed in lung tissues averaging out the potential for damage by lowering the rate of irradiation at any point[39]. These researchers state[39] that particles are surely not evenly distributed, but that the assumption of uniform distribution allows a better estimate of allowable lung burden standards then does the hot particle notion. Finally, it has been suggested[41] that the hot particle notion may be altogether misleading and that

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* Particles of diameters less than 0.01 micrometer (millionth of a meter) are sometimes called monomeric; polymeric refers to particles between 0.01 and 1 micrometer.[40]

a more even distribution of particles in lung tissue may represent the greatest potential danger. The Task Force feels it is important that the public understand how controversial this area of study is; we feel a great deal of study will be required (1) to fully understand the distribution of plutonium materials in the lungs and tissues of exposed people, and (2) to with certainty set radiation standards for lung burdens.

(f) Threshold Limits to Radiation Danger

There has always been the question of whether with various types of radiation there is a threshold limit below which such radiation causes no damage[26]. The complications arising from any attempt to study the existence of a threshold limits are staggering to imagine and it has been assumed, for the sake of erring on the conservative, safe side, that no such limit exists. Basically those who develop radiation standards assume that any radiation, no matter how seemingly insignificant, is capable of causing damage. The standards produced assess the possible risks from radiation. In this chapter we will try to indicate some of the biological phenomena potentially causing damage.

B. Environmental Pathways of Plutonium to Man

There are several ways that plutonium materials can ultimately reach man:

Release of plutonium materials to air

(1) direct inhalation by man

(2) inhalation by animals who are food sources of man

(3) settling to soil, uptake by plants, and dispersal directly to man or to animals and then to man

(4) settling to water, direct uptake by man or by animals and then to man

(5) settling to water, uptake by aquatic animals or plants and dispersal directly to man or to animals and then to man

Release of plutonium materials to water

(1) direct uptake by man or animals and then to man

(2) uptake by aquatic animals or plants and dispersal directly to man or to animals and then to man.

We will see in Section D that different routes of uptake by man (inhalation, ingestion, etc.) can lead to differing distributions of plutonium in the human body. There is a remarkable paucity of information on the various pathways of plutonium materials to man; we will indicate some of the information that is known with the admonition that most of what we say results from single studies of various subjects.

The concentrations of various radioactive materials (plutonium, uranium, tritium, strontium, and americium) have been measured in cattle grazing near the RFP[42]. Plutonium concentrations in both the lungs and the tracheo-bronchial lymph nodes of these cattle were elevated, comparable to the concentrations of cattle herds grazing near the Nevada Test Site. It was further determined[42] that some fraction of their exposure was attributable to inhalation of plutonium materials. We should note that the cattle grazed only half of the year on the land near the RFP and, as a result, levels in these cattle are not comparable to those on the Nevada Test Site. EPA figures[42] suggest that if a human were to ingest about a pound per day of these cattle for fifty years, his total radiation dose from this diet would be 0.02 rem. They imply that this is a very small fraction

of the dose received over this period of time from other sources in the Denver area. Other animal studies[7] indicate that animal uptake from plutonium bearing plants is about 0.00001 percent of the amount of plutonium in the plant.

Studies[2] carried out in the laboratory to measure uptake by plants from plutonium containing soils indicate that an average of about 0.00001 percent of the radioactivity is taken up by the plants. There is some indication[2] that plants do not uniformly take up plutonium with time, but may have increased uptake after two years of exposure. Experiments at RF in which actual field measurements are to be made have only recently begun[2]. There are recent indications that uptake by plants may be great under some conditions[35]. Further study is certainly required.

One of the critical problems yet to be fully understood is how much plutonium which has settled into soil is resuspended in air in respirable form. The problem is a difficult one since many factors control resuspension. For example, newly deposited material is more readily resuspended than older material. The size of deposited material, the size of the soil particles, the composition of the deposited materials, the composition of the soil--all of these are important factors, yet ones that are difficult to study. Efforts[2] are being made by the RFP to study these factors at least with respect to the RF environs. The Task Force feels that such studies should proceed rapidly so that a more basic understanding of the potential threats to health can be made.

On a more global scale some very preliminary studies[7] of plutonium concentrations in marine environments suggest that plutonium concentrations may be high near shore. This is contrary to what one might have thought; namely, that plutonium would be widely distributed and diluted in oceans. Other indications

are[7] that plutonium materials in marine sediments may be resuspended and that marine plants and animals can concentrate plutonium materials.

Perhaps the most important question we can address in this section is how likely is it that significant quantities of radiation can reach man through the food chain. Some estimates[2] would allow 0.001 percent transfer of plant activity to an animal gastrointestinal tract and a 0.001 percent transfer of activity to the human gastrointestinal tract by ingestion of the animal. It is clear that the food chain route of plant to man just described represents an enormous dilution of radioactivity. If initial soil levels are low it seems that the dangers to man are minimal. Nevertheless, we reiterate that levels must be kept low and that any dose to man is biologically undesirable.

C. Animal Studies with Plutonium

(a) Types of Animals

A variety of animals have been used in the biological studies of plutonium materials. Among these are several types of rodents, rabbits, pigs, and dogs. The majority of studies have been carried out with either rodents or dogs, but for the purposes of this report, we will be concerned mainly with the dog experiments. This is because they more closely parallel what we know about human subjects than do the rodent studies[39].

(b) Administration of Doses* and Dose Size

There are several pathways by which plutonium materials can enter an

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* It should be clear that in this chapter the word dose is used in the medical sense. That is, it is the administration of a material not a radiation dose.

experimental animal:

(1) ingestion

(2) inhalation

(3) intravenous injection

(4) introduction into surface wounds

To fully understand an experimental animal system, a complete analysis of the distribution of plutonium for each mode of entry is essential. As well, we must understand how rapidly plutonium material is translocated and eliminated from the animal. This requires a great deal of effort and is fraught with difficulties.

In general we can say that (1) plutonium materials that are soluble (e.g., plutonium nitrate) are more easily and rapidly translocated than highly insoluble compounds[39,41] (e.g., plutonium oxide) and (2) very small insoluble particles tend to behave like soluble ones in that they more rapidly move within the animal systems[41].

We also indicate that, in general, dose sizes in animal studies have been large[39,41] giving demonstrable effects, but ones which, perhaps, are not comparable to the effects to be expected from exposures at or near the RFP. Only recently have long-range experiments on beagles experiencing low level radiation doses been started[41].

(c) Distribution of Plutonium Material in Animal Studies

Only limited studies on the ingestion of plutonium materials in animals other than rats have been carried out. Nevertheless, it seems clear that only relatively small amounts are absorbed by the gastrointestinal tract; soluble

materials are more readily absorbed than insoluble ones; young animals absorb more plutonium materials than mature ones. Materials absorbed by the gastrointestional tract are ultimately deposited primarily in bone and to a lesser extent in liver, endocrine glands, and gonads. [39] * Material not absorbed is largely excreted.

Studies on the inhalation of plutonium materials have been numerous undoubtedly because this is the most likely mode of entry into humans. In a very general way, we can say that inhaled plutonium materials can suffer either, or both, of two fates.[41] The first possibility is that the plutonium material will be deposited in the ciliated** portion of the respiratory system and relatively quickly brought up to the throat where it is swallowed and then distributed much as plutonium materials that have been ingested. Deep penetration into the non-ciliated portions of the lungs is the other fate of plutonium particles[41]. In such penetrations, there are several routes[41] by which plutonium materials can be cleared: (1) transport by specialized "engulfing cells" back through the lungs and throat where it is largely ingested (2) transport into the lymphatic drainage system of the lungs and ultimately to other organs, and (3) solubilization of plutonium materials and transfer to the blood.

The most significant point about the clearance routes discussed is that they are slow. Each ultimately transports plutonium materials to other organs with relatively small amounts being excreted. The actual details of the beagle lung studies[39,41] which have led to the above generalizations are beyond the

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* A very recent review of gonad concentrations in man and animals has been published: C. R. Richmond and R. L. Thomas, Health Physics, 29, 241 (1975).

** Cilia are hairlike appendages on certain cell surfaces capable of a vibrating movement which tends to translocate materials past the cell surface.

scope of our report; it should be pointed out that many factors such as plutonium particle size and composition are important in the final distribution of material in the lung. It is clear that inhalation captures plutonium materials both efficiently and for a very long time. The dangers associated with this behavior are discussed in section (d).

Intravenous injection of plutonium nitrate solutions[39,41] indicates that about 90 percent of the plutonium becomes bound to a blood protein which transfers iron. Transfer of plutonium occurs largely to the bone or liver. Depending on the concentration of plutonium solutions (containing either mono- or polymeric plutonium), researchers have seen either very rapid or slow removal of plutonium from the blood. In either case, liver and bone and to a lesser extent spleen and bone marrow are the critical organs for deposition.

Plutonium nitrate deposited in wounds is readily absorbed and transported largely to bone with some liver deposition. Neither plutonium metal nor oxide are readily absorbed. Some experiments with beagles indicate that accumulations in the lymph system occur[39]. The studies of wounds have little relevance to the RFP simply because workers who have plutonium deposited in wounds are treated rapidly by decontamination procedures. Absorption and transport of material from the wound site are minimized (if not eliminated) by these procedures.

(d) Pathology in Animals

Pathology is the science concerned with the study of all aspects of disease. In this section we will attempt to indicate what manifestations of disease are caused by the various distributions of plutonium materials just described. We emphasize that these are what have been seen in animal studies and that, in most cases, we don't know yet whether similar manifestations

occur in humans.

Blood[39,41]:

Rather large doses of plutonium materials (either by injection or inhalation) cause reduction of the numbers of white blood cells within a few weeks. No leukemias have been reported in dog experiments although in rat populations leukemias have been noted. There appear to be only minor effects in the blood because of the fairly rapid removal of plutonium materials.

Bone[39,41]:

Malignant tumors in the bones of dogs have been reported with a wide variety of plutonium materials administered by different methods. Extensive work with dogs over many years has produced risk estimates. These are estimates of the probability of tumor occurrence in animals which have received a certain dose. Because the doses these animals received are in excess of what humans might be exposed to, we feel these studies are of limited value. On the other hand, the value of animal studies rests in their use as warning devices for potential threats to human health. We expect that the low radiation level long-term dog studies now in progress will be more applicable to humans. Finally, we note that massive doses of plutonium compounds administered intravenously cause severe skeletal damages producing high incidence of bone fractures in dogs.

Liver[39,41]:

Only quite limited information exists on liver tumors in dogs. These develop after long periods of time (longer than bone tumors) causing little life shortening in the dogs studied; again, the doses were high. Other changes in liver tissues were detected in shorter times when lower level doses were

administered.

Lung[39,41]:

Acute lung effects in dogs have been observed from single large doses. Severe inflammatory reactions, edema, hemorrhage, and usually death, occur within a few days. Lower doses cause fibrosis, the formation of a fibrous tissue in the lung, producing reduced lung function. Prolonged reduced lung function can cause lung insufficiency and associated heart failure in dogs. Long-term studies with beagles experiencing even lower doses* produced a high incidence of lung cancer. The types of cancer found in dogs are in the peripheral region of the lung in contrast with most lung cancers found in man which are frequently located in primary and segmented bronchi. Some concern has been voiced[39] that the levels at which some of these effects have been seen in beagles are only 100 fold higher than the human maximum permissible lung burden (MPLB). The most worrysome feature of this is that no data are yet reported on beagles at the MPLB levels.

Lymph Nodes[39,41]:

Some dogs inhaling plutonium oxide sprays (aerosols) develop thoracic lymph node malignancies. These are secondary to lung tumors in each case studied. Although the lymph nodes have received a higher radiation dose than the lungs, the primary malignancies developed in lungs. Again, radiation levels are fairly high and expectations are that the low level studies in progress will complement the data already accumulated.

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* The three respective doses indicated were: (1) greater than 0.5 microcuries per kilogram of lung, (2) 0.1 microcuries per kilogram of lung, and (3) less than 0.5 microcuries per kilogram of lung.

Studies in which plutonium oxide is implanted in the forepaws of beagles show that the plutonium is transported to the cervical and auxilliary lymph nodes. No evidence exists, however, that such treatment is detrimental to the dogs.

Gonads:[41,42]

All of the pathological effects just described are ones affecting the exposed subject (somatic effect). It is a matter of some concern to know what effect plutonium exposures will have on succeeding generations (genetic effect). Plutonium is deposited in the gonads of dogs, cattle, and humans. The Task Force believes too little definitive information is available and believes additional study is essential.

D. Human Studies with Plutonium

(a) Subjects[39,41]

Human subjects exposed to alpha radiation fall into several groups: (1) the general world population experiencing nuclear fallout (2) uranium miners experiencing radon and its decay products, and (3) occupationally exposed workers like those at the RFP.

Each of these groups is difficult to study. The world population not only experiences internal radiation from fallout, but receives other "background" radiation from sources like medical X-rays, cosmic radiation, and building materials. To sort out the effects of these sources and to attribute these to specific radiations would be exceedingly difficult. The best that can be done is to treat the population statistically and to estimate from other knowledge the risks to the general population. Uranium miners experience not only world-wide fallout, but exposure to alpha and gamma radiation from their mining environment. Studies

of the effect of alpha radiation on uranium workers are complicated because they inhale rock dust, diesel engine exhaust, and other materials as well. Occupationally exposed workers like those at the RFP experience fallout as well as the radiation exposures from their work. Such exposures are normally of fairly low levels although some individuals have experienced more serious exposures through accidents. In this section, we will deal mostly with occupationally exposed workers exposed above normal* levels. It is essential to recognize not only that thorough studies are lacking for workers exposed at normal* levels, but also that should such a study be started it will have to be of long duration and great expense to properly assess the dangers of exposure to the normal levels of alpha radiation experienced by radiation workers.

Only rarely[39] have humans been used in studies to assess the biological effects of plutonium. When such has been the practice, the subjects have been seriously ill patients. Attempts have been made to use occupationally exposed workers as study subjects, but these are often fraught with difficulties unless some good measure of the dose and its composition can be made.

(b) Distribution of Plutonium Materials in Humans[39,41]

While direct ingestion of plutonium materials is not a probable mode of entry in humans, the ingestion of contaminated food represents a potential hazard. Estimates of absorption in the gastrointestinal tract in humans derive from animal experiments and indicate very low absorptions.

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* By normal we mean levels of radiation exposure experienced by workers in a well controlled working situation. Above normal levels are those associated with increased exposures resulting from accidents.

Accidents involving workers can result in inhalation exposures. Some of these exposures have been to plutonium oxide and seem to suggest that humans can more rapidly clear plutonium from their lungs than dogs. This more rapid clearance should not disguise two important points: (1) lung retention times are still quite long, and (2) translocation of plutonium from the lungs leads to its deposition in other organs.

Plutonium nitrate and citrate, the latter a soluble compound, have been injected into humans. The nitrate was injected beneath the skin (simulating a wound) and relatively rapidly absorbed from the injection site. Within four hours, 3½ percent absorption had occurred.

Intravenous injection of the citrate results in rapid clearance of most of the plutonium from the blood. Yet, after as long as twenty days, there is still as much as one percent plutonium citrate circulating in the blood. The rapid clearance suggests that any therapy for that fraction of plutonium reaching the blood from an accidental exposure must be immediate to insure that deposition in various organs is minimized. Organ depositions from intravenous citrate injections are as follows: bone, 66 percent; liver, 23 percent; spleen, 0.4 percent; and kidney, 0.4 percent.

Little plutonium is absorbed through the skin in cases where there are no wounds. One accident occurring under conditions favorable to skin absorption resulted in only a 1/100 percent uptake.

Direct measurements of retention of plutonium in various organs have not been made, but estimates derived from excretion studies of terminally ill patients suggest that only half of injected plutonium would be excreted in two hundred years. Additional data beginning to accumulate from occupationally exposed autopsy specimens indicate large lung, liver, bone, and lymph node depositions.

(c) Pathology in Humans[39,41]

According to many groups "no cancers or detrimental biological effects"[41] have been found in humans as a result of plutonium exposures. Several important points need to be made in this regard. Most important is that experimentation must be accelerated. The various animal studies alert us to potentially serious problems. Further details on animals are essential as are long-range studies of occupationally exposed workers. Only a large study of long duration will be able to sort out the effects of long-term exposure to low level radiation. The Task Force feels that effects may be uncovered and takes seriously indeed its responsibility to urge that resources be quickly forthcoming to initiate studies of sufficient scope and design. (See Recommendation 5).

(d) Risk Estimates in Humans[43,44,45,46]

The concern just expressed results from our examination of risk estimates to humans subjected to radiation. The BEIR report[43] and scientists including Gofman[44] and Cohen[45] have outlined in detail the estimated effects, both somatic and genetic, on populations exposed to low level radiation. The effects estimated by different groups[43,44,45] vary widely since there are at the present time many uncertainties in the data used for such estimates. Although it is impossible to decide which is the most accurate, each estimate indicates that there are risks to low level exposure to radiation. In addition to these more general estimates the Task Force sought[46] information which could be applied to the RFP. These estimates, supplied by A. J. Hazle of the CDH, are based on air and water monitoring data for areas in close proximity to the RFP. The air data measurements of plutonium resuspended from plutonium contaminated soil can be converted into risk estimates. The method used[46] is a reasonable conservative one and has been reviewed by both the EPA and ERDA. In essence risk estimates are provided

for a population living for 70 years on soil contaminated at the CDH soil standard. An excess of approximately 2 individuals per 1,000,000 persons are estimated to die from such exposure (this compares with about 500,000 people who would die from all causes and about 3,000 deaths from exposure to natural background radiation). Similarly estimates of genetic effects caused by such plutonium contamination in soil are less than those to be expected from background radiation. The Task Force also received estimates of the effects of known concentrations of plutonium in the Broomfield water supply (the tritium concentrations are too low to produce any significant risk). These indicate that less than 1 individual per 1,000,000 might die from such exposure. Although it may appear that the numbers resulting from the RFP emissions are insignificant, the Task Force takes the position that any excess above the already elevated Colorado background is undesirable. We commend the efforts at the RFP to reduce emissions to as close to zero as is technically and economically feasible. Yet we urge that every effort be made to advance technology as rapidly as possible indicating that economic factors be given less emphasis when the potential for health damage exists.

(e) Medical Treatment for Plutonium Contamination[39,41]

There are three main procedures for removal of plutonium contamination in humans. The first, excision, is effective with wound contamination. Injection or infusion of agents that complex plutonium has proven fairly effective when contamination is plasma-born and recent. Such treatments remove some newly deposited plutonium in bone and liver. The key to this treatment is speed; it proves to be largely ineffective for plutonium depositions of long standing. Finally, the technique of lung lavage (washing), although quite dangerous, has been used in one case of massive inhalation burden. Only 13 percent of the

initial lung burden was removed even though experiments with dogs remove about 50 percent of inhaled plutonium oxide.

CHAPTER VI

Impact of the RFP on Its Workers and the Residents of Colorado

Introduction:

In some respects this chapter is a catch-all gathering together certain important aspects of the RFP either treated too superficially or not at all in earlier chapters. The intention is to discuss various alternatives that both workers and the citizens of Colorado have to react to any unfavorable impact on them from the RFP. We will briefly review not only the contractual agreements now in effect at RFP, but also legislation and other important information about the RFP.

A. The Rockwell-AEC Contract

The contract for the operation of the RFP between the Rockwell International Corporation and the U.S. Government acting through the AEC (now ERDA) became effective on June 30, 1975. Details have been discussed in our preliminary report, so we will only highlight certain aspects here. The contract defines the scope of Rockwell's work as well as its obligations with respect to the health and safety of the RFP workers. The Task Force has raised the question of whether Rockwell has any specifically designated obligations different from those of its predecessor. The term of the contract is five and one-half years with a somewhat flexible fee to be paid to Rockwell depending both upon the nature of the work pursued and various impact costs. It seems important to point out that the RFP

can hardly be viewed as a normal business--its product is not marketable and its costs are not within the realm we normally use when considering normal business ventures. As a result, the Task Force has taken the approach (several times in this report) that expense is secondary to either the necessity of resolving a specific question or providing some special protection. It is our view that this "extraordinary business" controls its own technology and that expenses are not measurable in ordinary economic terms. Application of the "nuclear deterrent philosophy" incurs tremendous expense; the Task Force hopes the public understands this but in addition takes the position that extraordinary efforts can be made to solve problems associated with the health and safety of the RFP workers and the residents of Colorado.

The Task Force in its preliminary report indicated that the Rockwell contract did not specifically provide for the preservation of individual worker's occupational radiation exposure records. We have been assured by Rockwell[31] that (1) such records are and will continue to be preserved, (2) will be disseminated to the individual workers, and (3) will be available, altered only to preserve confidentiality, for research workers. (See Recommendation 7 B, C).

B. Dow Chemical Company-United Steelworkers Agreement

Rockwell International and the United Steelworkers have very recently signed a new labor agreement. Our comments on the labor contract are based on the last Dow-United Steelworkers Agreement[47] since the new agreement is not yet available. There are, however, no substantial changes in the new contract in those areas we will comment on.[48] The contract covers all "hourly-paid production and maintenance employees"[47] at the RFP. Since a complete appraisal of the labor agreement is beyond the scope of the Task Force's duties, we will

comment only on the health and safety aspects of the agreement. The contract provides that (1) the Company (Rockwell) must supply all the protective clothing and equipment necessary for the health and safety of employees, (2) medical examinations be mandatory for hiring purposes and upon termination and required during employment in those areas indicated by the Company, (3) upon written request an employee may receive his occupational radiation exposure record, (4) any employee who exceeds the radiation exposure limits will be immediately notified, (5) any terminated employee will receive a written summary of his radiation exposure upon his written request, and (6) that a Joint Safety Committee (Company and Union) supervise not only safety inspections and safety meetings, but also deal with grievance problems related to health and safety.

C. Price-Anderson Amendments (1954) to the Atomic Energy Act

Our preliminary report discusses the Price-Anderson amendments in detail. Only a few comments seem necessary. The amendments provide in part that the U.S. Government agrees to indemnify its contractors in the event of a nuclear accident (up to $500 million). Such provision applies only to offsite injuries or property damage. There is some question about defining nuclear accidents since at present the determination of whether to label an accident as a nuclear incident or an extraordinary nuclear occurrence rests with the AEC (presumably both ERDA and the Nuclear Regulatory Commission). The statute of limitation on a claim resulting from a nuclear accident is ten years. Although by the standards of most accident cases this is a very liberal limit, the Task Force notes that somatic effects of radiation exposure may not show up for twenty to thirty years or longer. (See Recommendation 13 B)

D. Colorado Radiation Control Act, Colorado Revised Statute (CRS)(1973), 25-11

This statute defines the powers of the Governor and the Colorado Department of Health in dealing with the hazards of radiation. These are detailed in the preliminary report. Perhaps the most important point we should make is that the CDH in a 1975 amendment to this 1973 CRS is no longer specifically barred from entering Federal facilities. It is not clear whether this amendment really gives the CDH any power since it has yet to be used. Although the relationship between the RFP and the CDH is a harmonious one, the CDH still enters and leaves the RFP only with the approval of management. The Task Force voices concern believing that in the best interests of the citizens of Colorado, Rockwell should be required by ERDA through its contract to allow the CDH to carry out onsite inspections. Such inspections should be in those areas where the CDH has jurisdiction in non-Federal facilities. (See Recommendation 15 A).

E. Colorado Occupational Disease Act, Colorado Revised Statute (1973), 8-60-111

The Colorado Occupational Disease Act takes into account the possibility that effects of radiation exposure may not surface for many years. As a result, workers or their families are protected and may file claims up to three years after the commencement of disability or death. (See Recommendation 5 F).

F. Colorado Disaster Emergency Services Act, Colorado Revised Statute (1973), 28-2-101 to 405

Two of the expressed purposes of the Colorado Disaster Emergency Services Act are (1) reducing "vulnerability of people and communities of this State to damage, injury, and loss of life and property resulting from natural or manmade catastrophies, civil disturbance, or hostile military or paramilitary action," and (2) authorizing and providing for "cooperation in disaster prevention,

preparedness, response, and recovery." The Act creates a Division of Disaster Emergency Services within the Department of Military Affairs (DMA) responsible for creating and coordinating disaster response. An agreement between the DMA and the CDH concerning emergency response to radiation disasters is to be signed shortly.[49] The Governor, in 28-2-110, is given the power to "consider steps that could be taken on a continuing basis to prevent or reduce the harmful consequences of disasters." The Governor's powers to prevent a disaster conceivably could be stretched to allow control of some operations at the RFP.

G. Land Use, Zoning, and Building Requirements

The RFP has purchased additional buffer land as earlier described. The Task Force has examined the question of what other measures could be taken (1) to further buffer the RFP from its environs and (2) protect any nearby residents from potential health hazards.

The State regulation pertaining to radiation control was amended in 1973[50] to include plutonium contamination in soil. The amendment indicates that plutonium contaminations in excess of 2.0 disintegrations per minute per gram (0.01 microcuries per square meter) present "a sufficient hazard to the public health to require the utilization of special techniques of construction upon property so contaminated." Upon request the CDH will evaluate proposed control techniques.[50] This amendment points out the potential for danger without assigning any real regulatory power. The CDH does not have to be notified when someone builds on land contaminated above the 2.0 level. Luckily only small portions of land in the RF area exceed this level; until now these have not been particularly attractive to commercial enterprise. The Task Force urges that this land be purchased by ERDA or somehow decontaminated.

The potential for further soil contamination exists in the RF area. The Division of Disaster Emergency Services, in CRS 28-2-110(3), is authorized to recommend to the Governor any necessary changes in existing zoning, land use regulations, or building requirements.[51] Such recommendations must be based on evidence that a disaster of catastrophic proportions could occur without adequate warning. The Governor may not only recommend changes to the appropriate agencies or local governments, but also initiate legislative action. The Task Force has examined other measures that might control land use near the RFP (e.g., condemnation, rezoning, etc.) and has recommended that measures be taken to insure better control of land use surrounding the RFP. (See Recommendation 9 A-C).

H. Further Medical Considerations

The Task Force has taken a strong position on the need for a comprehensive study of the effects of low level radiation. We wish to point out that not only the workers at the RFP, but also workers at other nuclear facilities, nearby residents, their animals, and the local ecology must be included in the study. (See Recommendation 5).

I. The Transuranium Registry

The Transuranium Registry was established for the AEC to provide a central body for the accumulation and evaluation of data on the long-term uptake, distribution, and retention of plutonium (and other transuranic elements) in exposed workers. There has been poor cooperation between the Registry and workers; as a result only minimal autopsy data have been collected. The Task Force believes strongly that reorganization of the Registry is necessary to insure better participation in the program. (See Recommendation 5 A-C, 7 G).

J. Environmental Impact Statements (EIS)

Rockwell and ERDA have assured[22,31] the Task Force that no major actions can be undertaken at the RFP without the submission of an Environmental Impact Statement. Such assurances resulted from the Task Force's concerns about (1) the removal of the contaminated lip area, (2) the possibility of reprocessing spent fuel from nuclear power reactors, and (3) the potential for new secret work at the RFP. We strongly endorse the requirement that an EIS be submitted for all contemplated changes at the RFP. We, in addition, urge both the public and those who can expertly comment on specific EIS statements to examine these carefully and comment accordingly. (See Recommendation 12 B).

K. Nuclear Facilities Liability Act

During the 50th General Assembly (1975) the State of Colorado Legislature, House Bill 1488, a nuclear facilities liability act, was introduced. This Bill (see Appendix C for reproduction of 1488) passed in the House and was defeated in the Senate. The intent of the Bill was to better define the liabilities of nuclear facilities with regard to the public. The Task Force has voiced its concern that various other laws defining the RFP's liability may not provide adequate protection to the public. It believes that a Bill like House Bill 1488 represents a start at rectifying this situation. (See Recommendation 13C).

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45. B. L. Cohen, "The Hazards in Plutonium Dispersal," July, 1975.

46. "Rocky Flats Transuranics and Risk Estimates," submitted by A. J. Hazle of the CDH to the Task Force, August, 1975. This document was reviewed by EPA and the RF Area Office of ERDA.

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48. A phone call to Labor Relations at the RFP indicated that the health and safety aspects of the new agreement (Article XIV, Sections 8-11) are not substantially different from the earlier Dow agreement, August 6, 1975.

49. "Agreement and Memorandum of Understanding," between the Department of Military Affairs and the CDH. This has been signed by the CDH and we are informed will shortly be signed by the DMA.

50. Amendment to RH 4.21, April 19, 1973.

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LIST OF SPEAKERS AT LAMM-WIRTH APPENDIX A

ROCKY FLATS TASK FORCE PUBLIC HEARINGS

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Tom Rauch	935 Garfield St. Denver, Colo.	concerned citizen	115-118
Carl Lehrburger	70 Adams St. Denver, Colo.	People for Rational Energy Resources	119-127

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Dr. Eric Eisenbud	1619 Milwaukee	concerned citizen	133-141
Paul Wehr	Institute of Behavior Science, Room #1, Univ. of Colorado, Boulder, Co.	Sociologist, CU, Consortion on Peace Research, Education, & Development	141-151
Maury Wolfson	# 3, South Cook Denver, Colo. 80209	Environmental action of Colo. & People for Rational Energy Sources	152-158
Bill Pace	1639 E. 22nd Avenue Denver, Colo. 80205	concerned citizen	159-162
Ms. Pam Solo for Prof. Elise Boulding	2801 E. Colfax, Room 304 Denver, Colo. 80206	Sociology Dept., CU	162-174
Bernard Meyer	4044 17th Ave. Parkway Denver, Colo. 80220	concerned citizen	174-178
Cris Crosby	5060 E. Quincy Englewood, Colo.	concerned citizen	178-181
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ROCKY FLATS TASK FORCE PUBLIC HEARINGS

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Atomics International Division
Rocky Flats Plant
P.O. Box 464
Golden, Colorado 80401
(303) 494-3311
Contractor to
Energy Research and Development
Administration

Rockwell
International

August 1, 1975

75-RF-0240

Dr. Robert D. Siek, Chairman
Lamm-Wirth Task Force
Colorado Department of Health
4210 East 11th Avenue
Denver, Colorado 80220

Dear Dr. Siek:

Enclosed are five copies of Rockwell International response to questions posed by the Lamm-Wirth Task Force at their July 17, 1975 meeting.

Robert E. Yoder, Director
Health, Safety and Environment

REY:cmc
Enc.

cc:
W. M. Lamb - ERDA, RFAO
E. G. Kunz - AI, Rocky Flats
R. O. Williams - AI, Rocky Flats

RESPONSE TO QUESTIONS POSED
BY LAMM-WIRTH TASK FORCE

QUESTIONS:

"What has Rockwell International done in the safety area since they assumed operational responsibility of the Rocky Flats Plant and what items are under study or pending study?"

"What is being done regarding the size reduction area?"

Items Accomplished or Under Study

1. Rockwell International has reorganized the safety elements (i.e. Nuclear Safety, Health Sciences, Environmental Sciences and Waste Control, and Safety and Loss Prevention) into a single responsive unit reporting to the plant manager. This organizational approach should unify the several safety disciplines to provide a coordinate approach to problem solving, policy development and implementation, monitoring and audit.

2. A review of the safety program was conducted in the phase-in period to establish base line data for the delineation of problem areas requiring further review for potential corrective action.

3. The plant safety award program is being expanded to include more than industrial safety and lost time accidents. A study committee representing several plant employee units presented their recommendations to the Executive Safety Committee on July 30, 1975. A summary of their program concept is attached as Appendix A. These objectives are plant wide in scope and multifaceted. The goals represent a 20-30% reduction in last years' experience. An interesting feature of the suggested program allows partial reward for partially meeting goals. Experience indicates that a reward-no reward situation may increase the accident rate rather than decrease it.

4. An announcement has been made that individual employee exposure summaries will be provided to each employee on an annual basis. We expect to do this by July 1, 1976. If the necessary analyses can be accomplished sooner we will move to accelerate that date.

5. We are reviewing the size reduction operation and at your request are including data relative to the radiation background in this area. (Appendix B) It is our intent to initiate a program (which may require specific ERDA funding) to separate workers from the radioactive materials where possible through the use of remote or enclosed operations. We hope in this manner to eliminate the routine use of air supplied suits.

6. A review of the quality assurance requirements in personnel dosimetry (badge) is underway to determine how many and what type of blind badges are required as well as how the system can be automated. Consideration is being given to using a commercial service for independent checks.

7. The Health, Safety and Environment Director is now involved as a step in the resolution of safety concerns. Several pending items have been presented to him for his resolution and suggested priorities have been established by the union safety committee.

8. A generalized set of plant rules is under development to provide employees, in a single document, the basic requirements for safe, secure conduct. Each major building will have a short addendum to the general rules which specify additional requirements specific to the functions conducted therein.

9. An independent management audit function that reports to the General Manager has been established. The four organizations within the Health, Safety and Environment are scheduled for audit within the next 12 months. These audits are separate and independent of the ERDA annual audits by Health and Safety.

10. The worker classification lists are being reviewed to assure that each individual who has an assignment which involves a special material, e.g. beryllium, is included on the appropriate rosters and that each is notified of this inclusion in a roster. Each employee will receive the results of his periodic or any special medical examination.

11. The "stepoff" lines which demark the several radiation contamination zones are being reviewed and relocated to provide better contamination control and to include human factors motivation to stimulate people to monitor themselves as a natural and convenient act.

12. A revised schedule to develop complete ERDA Approved Safety Analysis Reports has been developed and is being submitted to ERDA for their approval.

13. The emergency preparedness program is under study to assure the clear assignment of responsibilities, that proper external mutual aid agreements are in force, and to provide coordinated training.

14. The St. Lukes Hospital agreement for radiological support has been transferred from Dow Chemical U.S.A. to Rockwell International. A change in corporate assignment for the agreement with the Medical Center, University of Colorado, Board of Regents regarding radiological support has been transmitted to the Regents and we are awaiting their action. The desirability of additional agreements is under internal discussion and we may augment this program if hospitals wish to participate.

15. A request for additional funds has been made to implement an analysis of the major buildings for their resistance to earthquake damage and to determine their integrity from a design basis earthquake as well. Critical systems (ventilation system, emergency power, fire suppression, etc.) will be evaluated similarly.

16. A contract is pending with a consultant to establish the basis of a maximum accident beyond that which is deemed credible. This accident is analogous to a class nine accident hypothesized for nuclear reactors (which we do not have).

Items Scheduled for Study or Those Whose Scope Is Being Defined

1. Procedures and methods to assure maximum analysis of environmental and in-plant monitoring data to assure the detection of anomolies or trends at the earliest possible time.

2. Review of the safety training provided to the several groups in the Plant.

3. Review and establish procedures and guidelines for formal review and sign off of all operations - such as production, research, maintenance, etc.

4. Review the health physics instrumentation resources, its maintenance and calibration.

5. Review the whole body (lung) counting program to assure proper dose assessment and assignment. This may include some independent personnel whole body counts by a commercial firm.

6. Initiate a review of safety manuals, guides, policies and rules to assure proper assignment of responsibility and to establish any needed new policies and procedures.

7. Conduct a review of the air sampling program both on and off site and in the work environment.

8. Initiate a disciplined approach to job safety analyses using "systems safety" techniques.

9. Pursue research program in air cleaning development to seek avenues for waste volume reduction.

10. Review the requirements for retention of monitoring records and provide an effective system to demonstrate the degree of cleanliness in work areas or support areas.

APPENDIX A

TOTAL SAFETY AWARD PROGRAM

A new total safety award program has been developed that encompasses the Industrial Safety, Fire Protection, Nuclear Safety, Health Sciences and Environmental Sciences functions.

The objective of the program is to involve all plant employees in all facets of safety, to improve overall safety performance at the Rocky Flats Plant, thereby minimizing or eliminating any adverse effects to the surrounding area, community or general population.

Areas to be included in the goals are nuclear safety, disabling and serious injuries, ERDA reportable incidents, effluent control, radiation dose reduction, reduction in the already low gaseous emissions, reduction in property loss or damage, and reduction in preventable vehicle accidents.

Plant wide goals have been established with incentive awards based on accomplishments of these goals. Progress or lack of progress in achieving these goals will be reviewed on a monthly basis by the Executive Safety Committee to insure continued emphasis on all goals and take corrective action if goals are not being met.

Point values have been assigned to each of the plant goals in order of their importance. These point values will be used to judge plant performance and eligibility for an incentive award to all employees.

Plant performance will be evaluated on a quarterly basis for the incentive awards and a determination made as to the level of award each employee will receive. Three levels of incentive awards have been suggested.

All goals are achievable but they will require a better than average performance on the part of all employees.

These plant goals will be reviewed annually and set higher if need be to continually improve the plant's overall safety performance.

APPENDIX B

A review of the size reduction area has been initiated. The basic data regarding external radiation fields shows that significant improvement was achieved in the February 1975 dose reduction effort. The quarterly (April-June) and semiannual (January-June) dosimetry results are attached. No workers are accumulating exposure at a rate which would exceed an individual exposure in excess of the 5 rem/year whole body limit or 75 rem/year hand limit (ERDA and statutory limits). Our internal objective is to limit the annual exposure to 3.0 rem which should be accumulated at as near constant rate as possible. It should be mentioned that these workers receive a pay differential for work in air supplied suits so that to equalize this remuneration the personnel are rotated. Supervision appears to have exercised prudence in maintaining exposures within operational requirements.

To further reduce exposure the following actions are being taken:

1. Conduct more frequent radiation surveys on a random basis (during operations) to determine dose extremes.

2. Prohibit transfer to size reduction of any material or package of materials whose contamination produces a dose rate greater than 50 millirem/hour without prior discussion and scheduling. This will insure better decontamination before transfer and permit pre-job analysis to accomplish the task in a minimum of time as well as prevent the accidental accumulation of material awaiting processing.

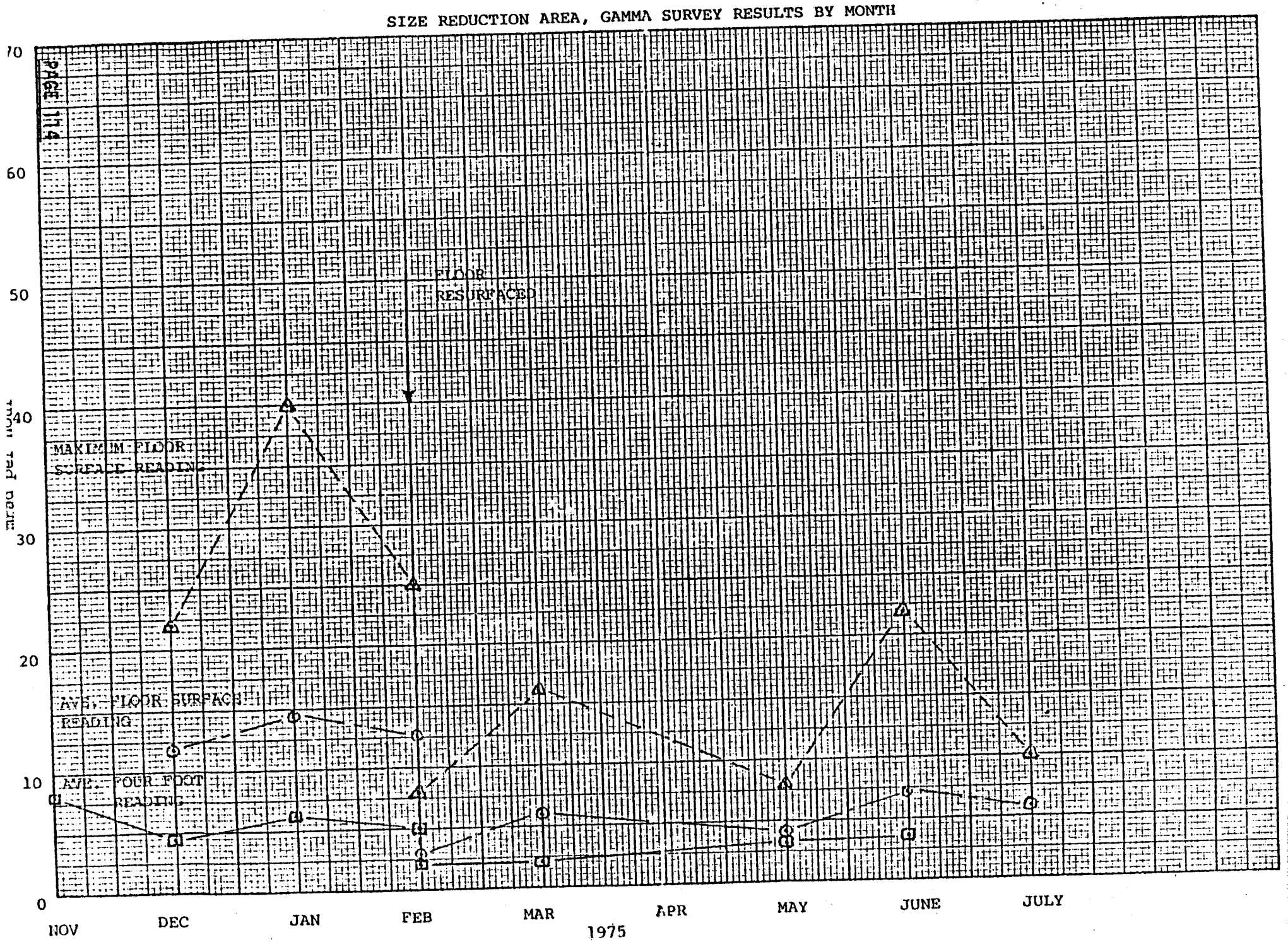
3. Review each routine task (e.g. waste water filter change) to provide improved shielding during the operation.

4. Survey the walls of the facility and if necessary recoat for easier cleaning or cover with a suitable material to shield any nonremovable contamination. (this action will depend upon the possible dose reduction which we may anticipate.)

5. Review the facilities and practices at other ERDA sites which have similar activities to glean information from their experience.

6. Request Research and Development to direct more of their remote engineering work to assist us in the design of new facilities or equipment.

7. Include in the Waste Management funding request to ERDA sufficient funds to design and build a new or modified facility for this operation. The design criteria and objectives have not been delineated; however, they will include as a minimum a remote operation, contained cabinets for radioactivity control, and a design basis worker dose accumulation of 1 rem/year.



PERIOD
QUARTER SECOND ONLY

YEAR 1975

WHOLE BODY EXTERNAL DOSE DISTRIBUTION FOR PLUTONIUM AREA GROUPS (MREM)

	0 To 125	126 To 250	251 To 375	376 To 500	501 To 625	626 To 750	751 To 875	876 To 1000	1001 To 1125	1126 To 1250	1251 To 1375	1376 To 1500	1501 To 1625	1626 To 1750	More Than 1750	Max. Body Dose
WASTE MGMT.		4	2	2	2	3		1	1							1045

QUARTERLY PRORATED LEVEL

PERIOD
QUARTER SECOND ONLY

YEAR 1975

HAND EXTERNAL DOSE DISTRIBUTION FOR PLUTONIUM AREA GROUPS (MREM)

	0 To 1000	1001 To 2000	2001 To 3000	3001 To 4000	4001 To 5000	5001 To 6000	6001 To 7000	7001 To 8000	8001 To 9000	9001 To 10000	10001 To 11000	11001 To 12000	12001 To 13000	13001 To 14000	More Than 14000	Max Hand Dose
STE MGMT.	5	5	4	1												3034

10,000 mrem - QUARTERLY PRORATED LEVEL

YEAR 1975

FIRST SIX MONTHS SUMMARY

WHOLE BODY EXTERNAL DOSE DISTRIBUTION
FOR PLUTONIUM AREA GROUPS (REM)

	0 To 0.499	.5 To 0.999	1.0 To 1.499	1.5 To 1.999	2.0 To 2.499	2.5 To 2.999	3.0 To 3.499	3.5 To 3.999	4.0 To 4.499	4.5 To 4.999	5.0 > 5.0	Max. Body Dose
WASTE MGMT.	2	6	5	2								1690

FIRST SIX MONTHS SUMMARY
HAND EXTERNAL DOSE DISTRIBUTION
FOR PLUTONIUM AREA GROUPS (REM)

YEAR 1975

	0 To 4.999	5 To 9.999	10 To 14.999	15 To 19.999	20 To 24.999	25 To 29.999	30 To 34.999	35 To 39.999	40 To 44.999	45 To 49.999	50 > 50	Max. Hand Dose
WASTE MGMT.	13	2										5231

APPENDIX C

Fiftieth General Assembly

STATE OF COLORADO

BY REPRESENTATIVE Burrows

A BILL FOR AN ACT

CONCERNING NUCLEAR FACILITIES, AND ENACTING "THE NUCLEAR FACILITIES LIABILITY ACT OF 1975".

Bill Summary

(NOTE: This summary applies to this bill as introduced and does not necessarily reflect any amendments which may be subsequently adopted.)

Provides for definitions pertaining to nuclear facilities and for the liability of the operator of a nuclear facility.

Be it enacted by the General Assembly of the State of Colorado:

SECTION 1. Title 13, Colorado Revised Statutes 1973, as amended, is amended BY THE ADDITION OF A NEW ARTICLE to read:

ARTICLE 21.5

The Nuclear Facilities Liability Act

13-21.5-101. Definitions. As used in this article unless the context otherwise requires:

(1) "Byproduct material" means any radioactive material (except special nuclear material) yielded in or made radioactive by exposure to radiation incident to the process of producing or utilizing special nuclear material.

(2) "Injury" means any harm to person or property for which damages may be recovered under the law of this state.

(3) "Nuclear facility" means:

(a) Any nuclear reactor;

(b) Any equipment or device designed or used for separating the isotopes of uranium or plutonium, processing or utilizing spent fuel, or handling, processing, or packaging waste;

(c) Any equipment or device used for processing, fabricating, or alloying special nuclear material if at any time the total amount of the material at the site where the equipment or device is located consists of or contains more than twenty-five grams of plutonium or uranium 233, or any combination thereof, or more than two hundred fifty grams of uranium 235;

(d) Any structure, basin, excavation, premise, or place prepared and used for the storage or disposal of waste, other than facilities utilized exclusively in connection with the transportation of the material; and
(e) The site on which any of the above is located.

(4) "Nuclear incident" means any occurrence:
(a) Causing, other than at the nuclear facility, bodily injury, sickness, disease, or death, or loss of or damage to property, or loss of use of property, arising out of or resulting from the radioactive, toxic, explosive, or other hazardous properties of source, special nuclear, or byproduct material;
(b) Caused by any reason, other than an act of war;
(c) Occurring either at the nuclear facility or in the course of transportation of source, special nuclear, or byproduct material to or from the facility; and
(d) As to which an indemnification agreement exists between the United States atomic energy commission and the operator in accordance with section 170 of the "Atomic Energy Act of 1954", as amended, whether or not indemnification under the agreement may be necessary.

(5) "Nuclear reactor" means any apparatus designed or used to sustain nuclear fission in a self-supporting chain reaction or to contain a critical mass of special nuclear material.

(6) "Operator" means the person with whom the United States atomic energy commission has executed an indemnification agreement in accordance with section 170 of the "Atomic Energy Act of 1954", as amended.

(7) "Person" means an individual, corporation, partnership, firm, association, trust, estate, public or private institution, group, government agency, a state or any political subdivision thereof, or a political entity within a state, a foreign government or nation or a political subdivision of any such government or nation, or other entity or a legal successor, representative, agent, or agency of the foregoing;

(8) "Source material" means uranium, thorium, or any other material which has been determined by the United States atomic energy commission to be source material or ores containing one or more of the foregoing materials, in any concentration as determined by regulation of the United States atomic energy commission.

(9) "Special nuclear material" means: plutonium, uranium enriched in the isotope 233 or in the isotope 235, and any other material which the United States atomic energy commission has determined to be special nuclear material or any material artificially enriched by any of the foregoing, but does not include source material.

(10) "Spent fuel" means any fuel element or fuel component, solid or liquid, which has been used or exposed to radiation in any nuclear reactor.

(11) "Waste" means any waste material resulting from the operation of a nuclear facility or containing byproduct material.

13-21.5-102. Liability - nuclear facilities. The operator of a nuclear facility is liable, without proof of fault, for an injury arising out of or resulting from a nuclear incident, other than an injury, compensable under a state or federal workmen's compensation act, of any employee employed at the site of and in connection with the nuclear facility or an injury to the nuclear facility or to property located at the site of and used in connection with the nuclear facility.

13-21.5-103. Application of article. This article applies to an injury suffered in this state arising out of or resulting from a nuclear incident either within or without this state or an injury suffered outside this state arising out of or resulting from a nuclear incident within this state.

13-21.5-104. Exclusive liability. If in any action an operator is liable without proof of fault under section 13-21.5-102 or a substantially similar law, either in this state or by application of controlling law rules, and if jurisdiction can be obtained over the operator in that action, the operator is exclusively liable, and no action may be brought against any other person with respect to the injury.

13-21.5-105. Limitations. No action may be brought under this article more than three years after the person suffering or incurring the injury knows, or reasonably could have knowledge of, the cause of the injury or more than ten years after the date of the last occurrence to which the injury is attributed, whichever first occurs.

13-21.5-106. Effect of other laws. (1) The provisions of this article do not affect, amend, or repeal:

(a) Any other rule or provision of law governing immunity to suit, the conditions and effect of a waiver of immunity, or the effect of the purchase of insurance upon the insurer or the insured;

(b) Any other provisions of law governing liability for injuries not covered by this article, limiting the amount of recovery for injuries covered by this article, or governing the kinds of injuries for which damages may be awarded; or

(c) Unless otherwise provided by this article, any other provisions of law relating to establishing and proving legal liability.

SECTION 2. Safety clause. The general assembly hereby finds, determines, and declares that this act is necessary for the immediate preservation of the public peace, health, and safety.